
# Ground-Water in the Clark Fork Basin

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Montana Ground-Water Assessment

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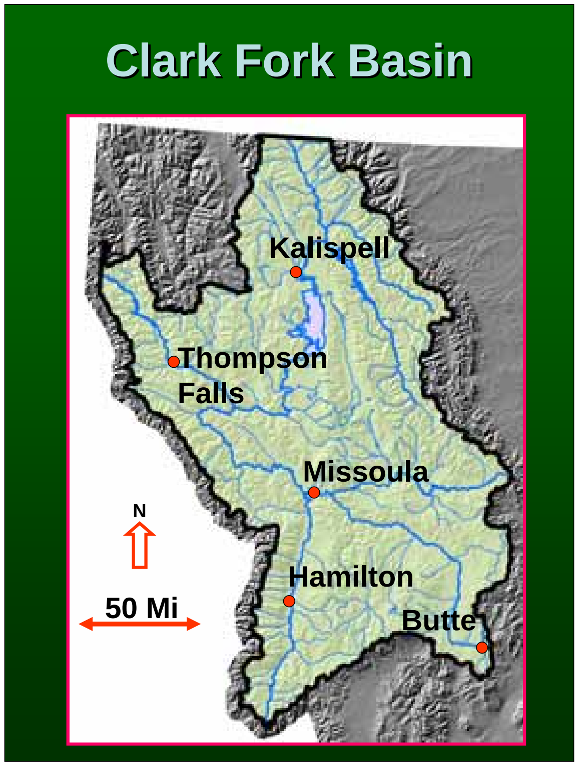
Montana Bureau of Mines and Geology
Since 1919
Earth Science Information

The Ground-Water Assessment Program at the Montana Bureau of Mines and Geology conducts aquifer characterizations for the state of Montana. To date the program has produced two atlases, 34 maps, and several open-file reports describing the hydrogeology of 14 Montana counties.

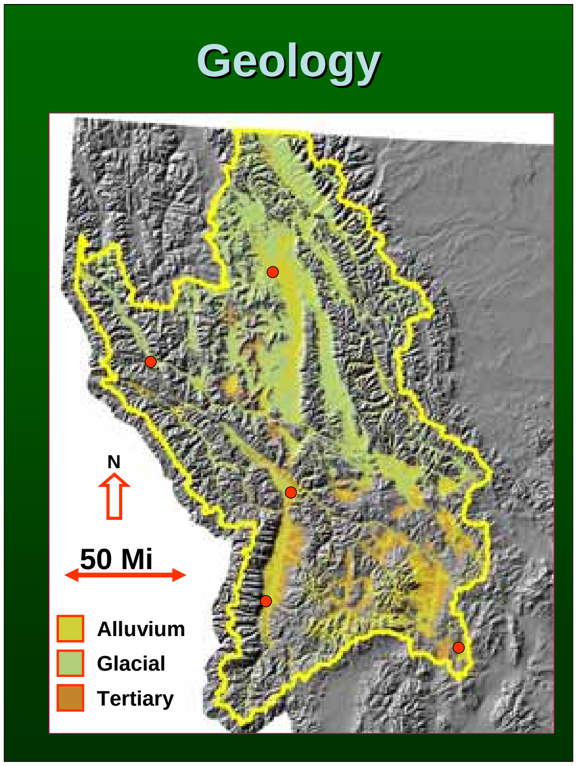
The Assessment Program operates a long-term monitoring network of about 900 wells from which it collects water-level and water-quality data. Long-term water-level records are useful when impacts from climate, development or other factors must be evaluated.

All data collected by the program is put into the Ground-Water Information Center (GWIC) database which in addition houses ground-water data for about 200,000 Montana wells. GWIC can be reached on the web at http://mbmggwic.mtech.edu.




The Montana portion of the Clark Fork basin covers about 21,459 square miles and extends from the river's head waters near Butte, Montana north along the Continental Divide to where the North Fork of the Flathead River enters the country from Canada. A portion of the basin extends northward from there into British Columbia Canada. The river leaves Montana below Noxon at its border with Idaho.

Much of the basin consists of intermontane valleys that began developing during the Tertiary and that are connected by relatively narrow, incised canyons.




The intermontane valleys are filled with sediment generally derived from surrounding bedrock. The sediment has been transported into the basins by smaller streams tributary to major through-flowing branches of the Clark Fork. These sediments may occur as alluvial fans along the valley margins but are often fine grained and may not be aquifers.

Alluvium is deposited along most streams and often contains the most prolific aquifers.

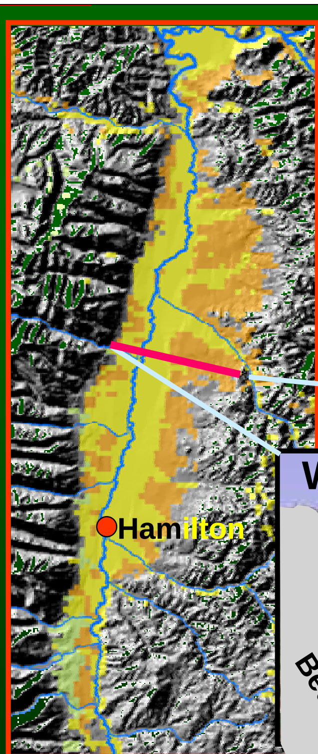
A thick well-sorted gravel was deposited in the Kalispell Valley by the Flathead Lobe of the Cordilleran ice sheet. Glacial Lake Missoula and its outwash floods modified the surficial geology in the southern part of the Flathead drainage and downstream of  Missoula, Montana.

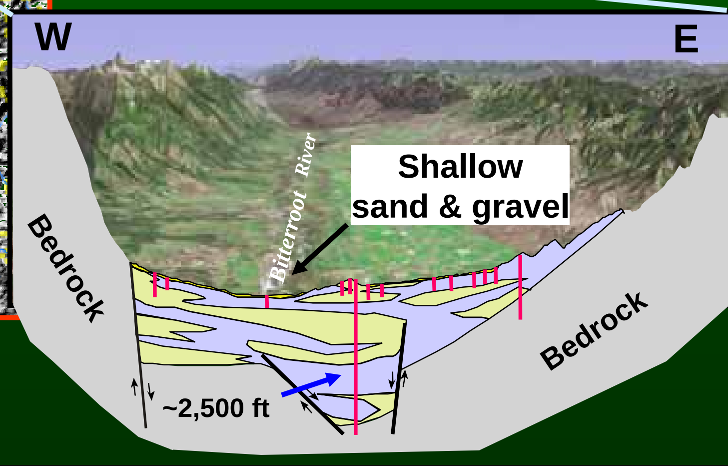
# Previous Work


- Kendy, E., and Tresch, R., 1996, Geographic, geologic, and hydrologic summaries of intermontane basins of the Northern Rocky Mountains, Montana, U.S. Geological Survey Water-Resources Investigations Report 96-4025, 233P.
- LaFave, J., Smith, L., Patton, T., 2004, Ground-water resources of the Flathead Lake Area: Flathead, Lake, and parts of Missoula and Sanders counties. Part A- Descriptive overview, Montana Bureau of Mines and Geology: Ground-water Assessment Atlas 2, 132 p, and part B, 11 plates.
- Smith, L., LaFave, J., and Carstarphen, C., Ground-water resources of the Lolo-Bitterroot Area: Mineral, Missoula, and Ravalli counties. Part B, 10 maps (open-file versions).

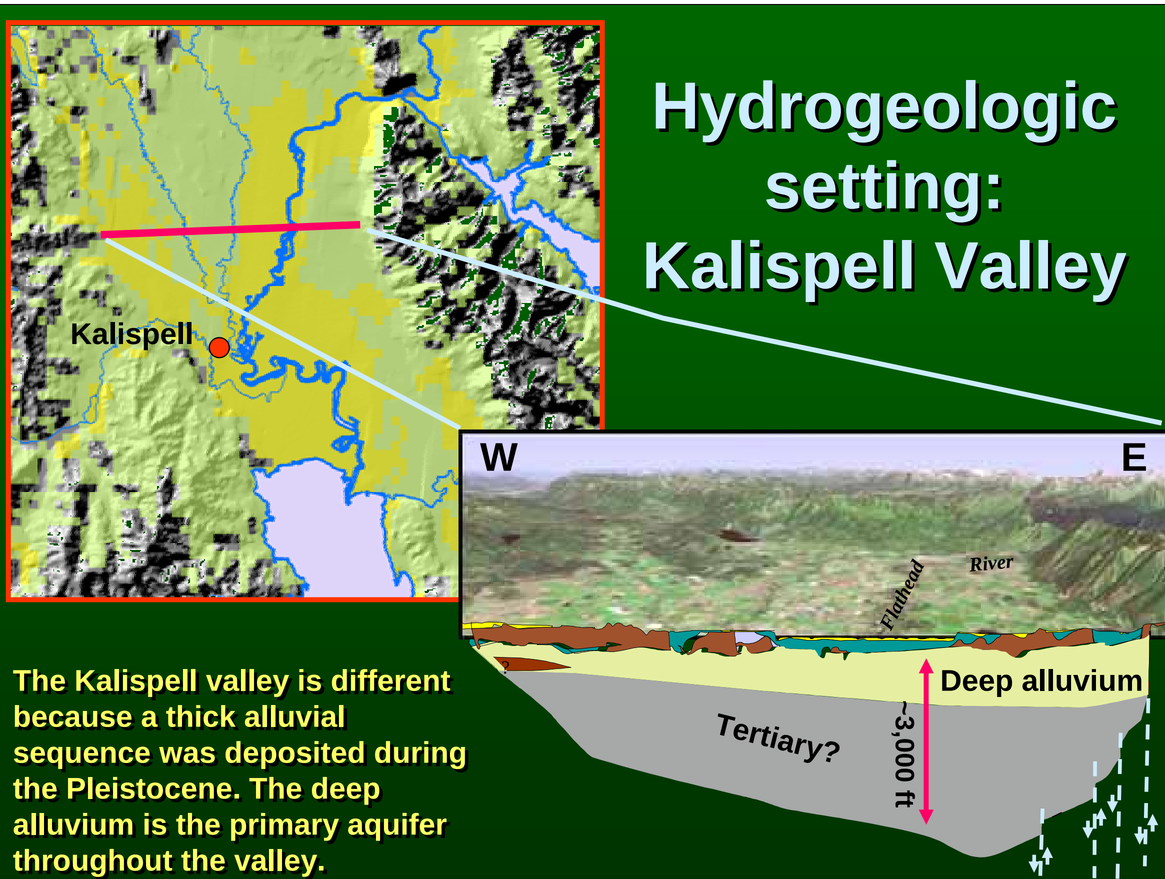
# Hydrogeologic setting: Bitterroot Valley

Represents valleys filled with debris from valley margins. May have channel deposits from through flowing streams more or less central in the basin. (Missoula, Deer Lodge, Drummond, others)



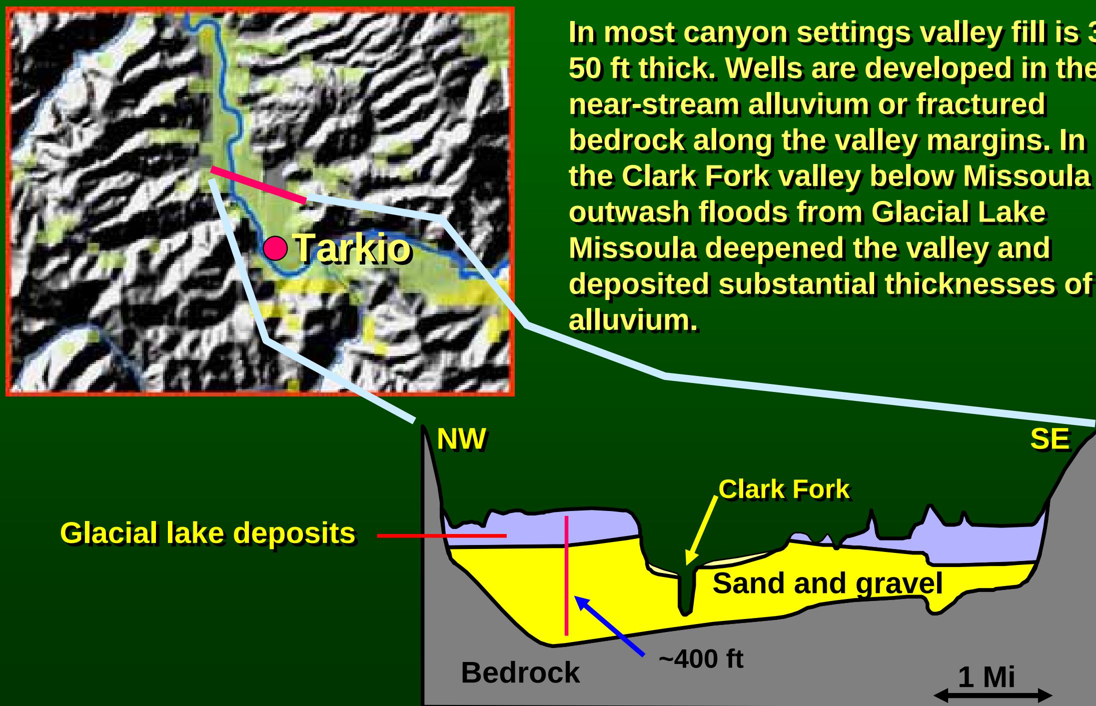



# Hydrogeologic setting: Kalispell Valley

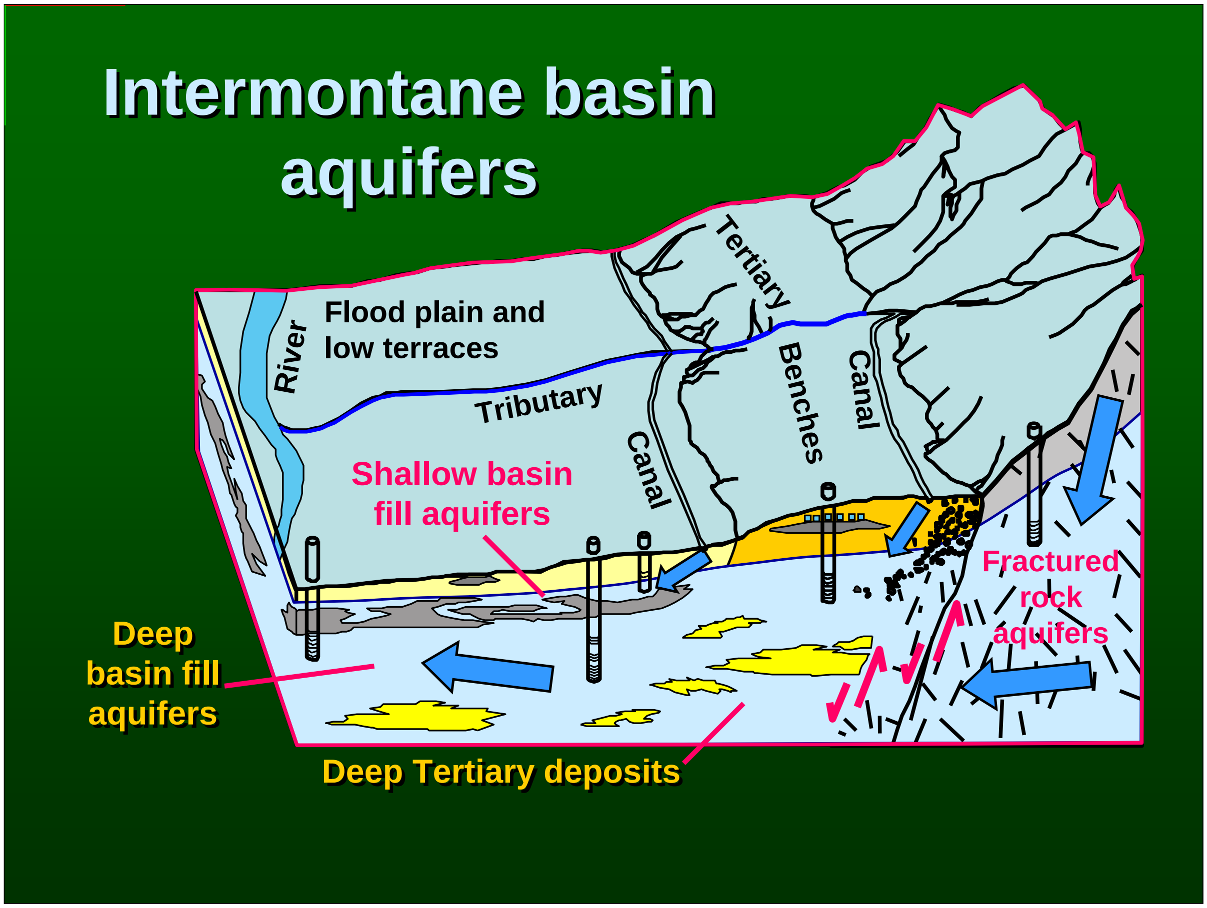



The Kalispell valley is different because a thick alluvial sequence was deposited during the Pleistocene. The deep alluvium is the primary aquifer throughout the valley.

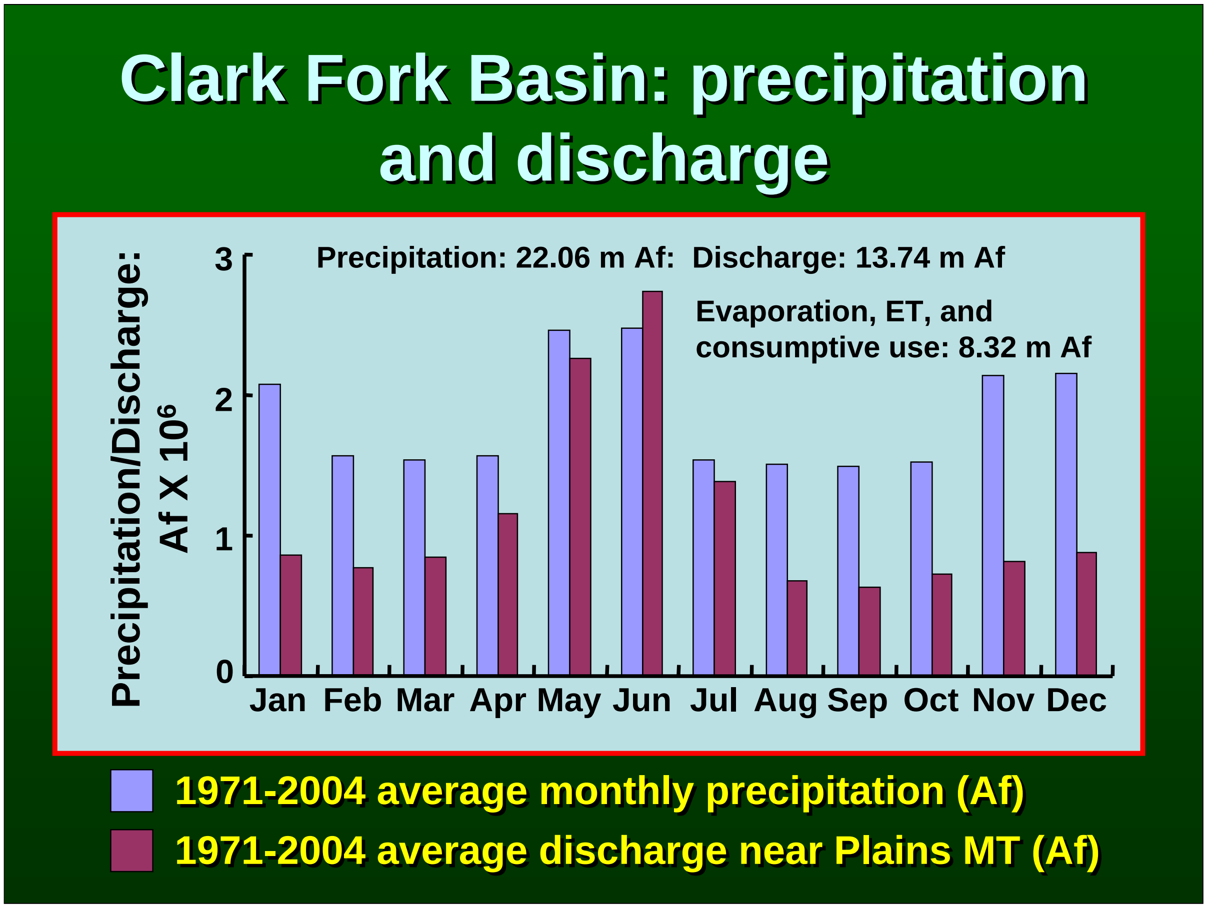
# Hydrogeologic setting - canyons




**In most canyon settings valley fill is 30-50 ft thick. Wells are developed in the near-stream alluvium or fractured bedrock along the valley margins. In the Clark Fork valley below Missoula outwash floods from Glacial Lake Missoula deepened the valley and deposited substantial thicknesses of alluvium.**

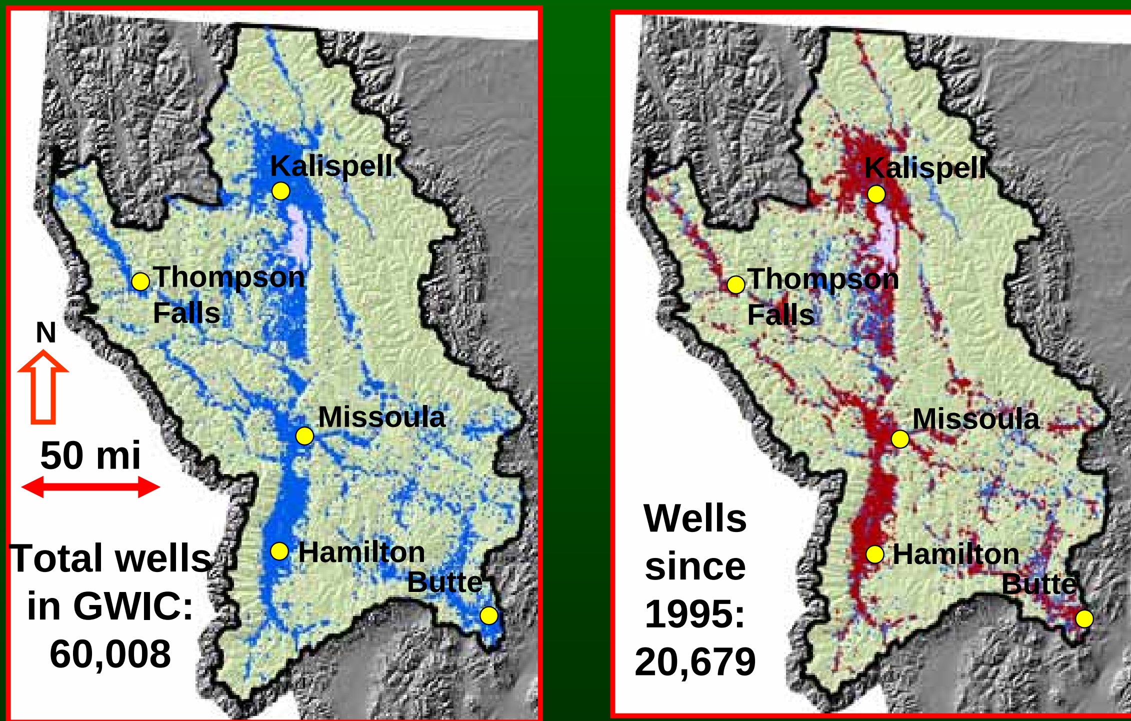



Ground-water flow in the intermontane basin aquifers is generally from the edges and upper ends to the center and then down valley. Important recharge sources are provided by tributaries and by irrigation canals. Water also enters the basin fill from the surrounding mountains as recharge. Confining zones may cause aquifers to be separated into near-surface and deep zones that locally may exhibit separation. However, the valley acts on a whole as a single hydrogeologic unit.



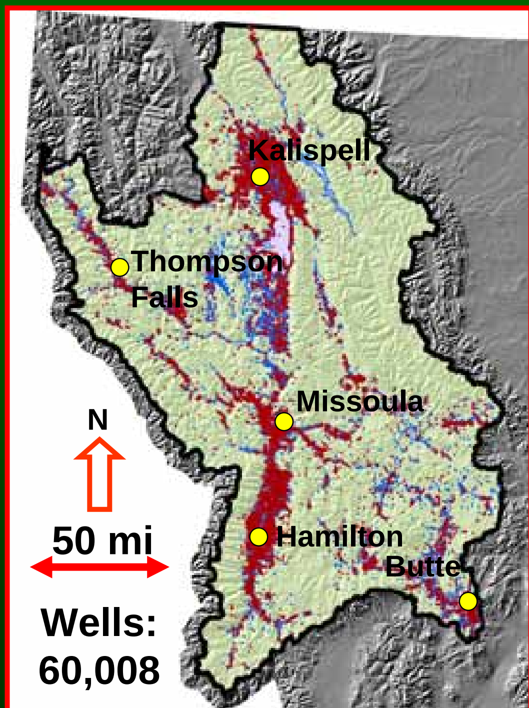

- Precipitation volume based on 1971-2004 monthly precipitation for the Western Climate Division. Precipitation data from the Western Regional Climate Center at http://www.wrcc.dri.edu.
- Discharge volume from monthly average flow data measured at USGS gage12389000, Clark Fork near Plains MT.
- The difference between water into the basin as precipitation water leaving the basin as discharge is made up by evaporation, evapotranspiration, and consumptive use.
- The volumes shown are to provide an “order of magnitude” for the amounts of water involved. Other measures may provide more refined numbers, particularly for precipitation.

# Clark Fork Basin water wells




- Ground-water development is significant within the basin. Logs for more than 60,000 water wells are recorded in the Ground-Water Information Center (GWIC) at the Montana Bureau of Mines and Geology.
- Is the development intercepting water that would become surface flow, and if so, are downstream (senior) water rights being impacted? Population in the basin is increasing and many of those moving into the area drill wells for domestic and other purposes.

# Ground-water development

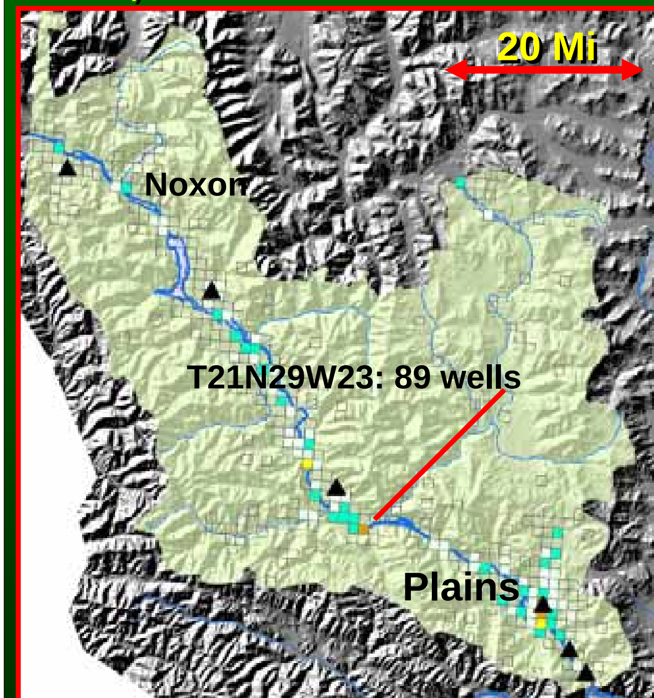


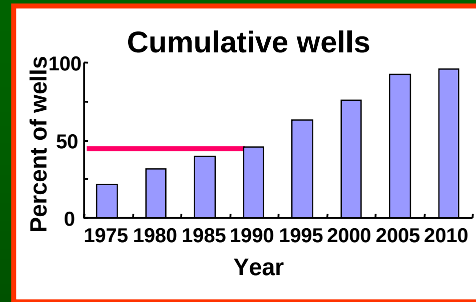

- Clark Fork basin above Milltown closed to new ground-water develop-ment without a SW/GW report and an augmen-tation plan.
- Well density maps provide a way to evaluate growth.

The next several slides detail well-drilling densities by sub basin and the numbers of wells drilled since 1990. In the notes pages are ancillary graphs showing the numbers of state wide monitoring wells, well uses, depth histograms, and construction rates.

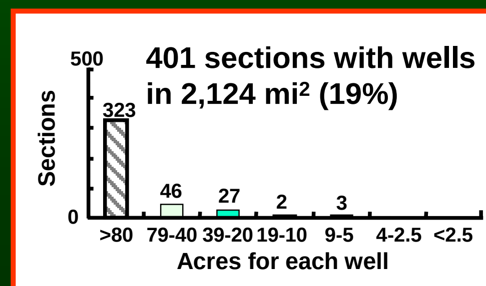
# Clark fork – below Flathead River

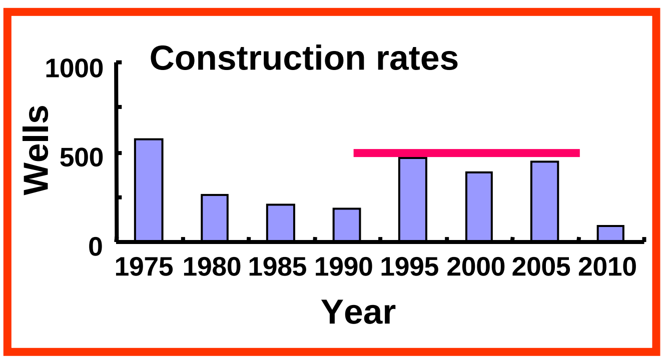
**2,529 wells: 87% Domestic**

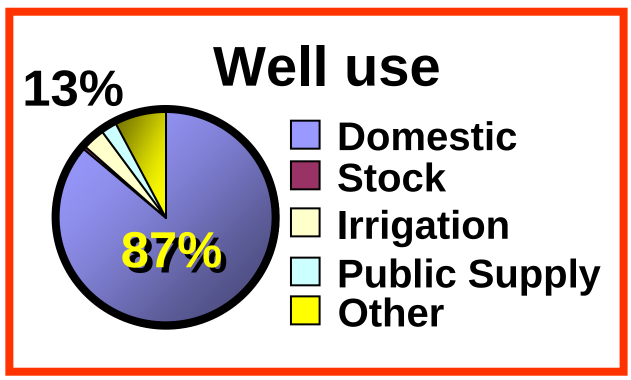


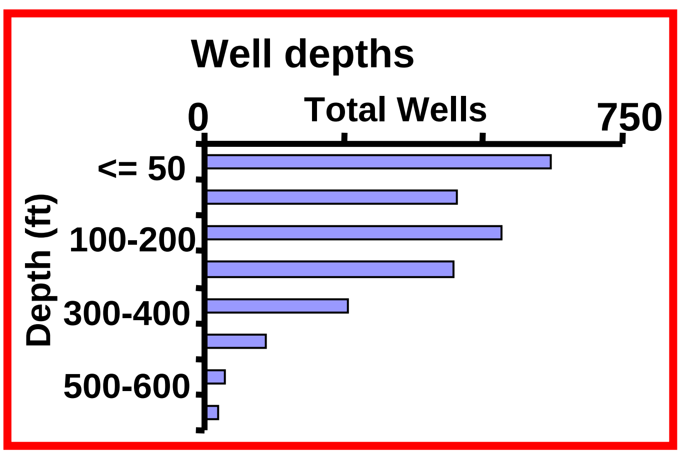




- 1 well/40 ac.
- 1 well/20 ac.
- 1 well/10 ac.
- 1 well/5 ac.
- 1 well/2.5 ac.
- 1 well/<2.5 ac.




## State wide Monitoring

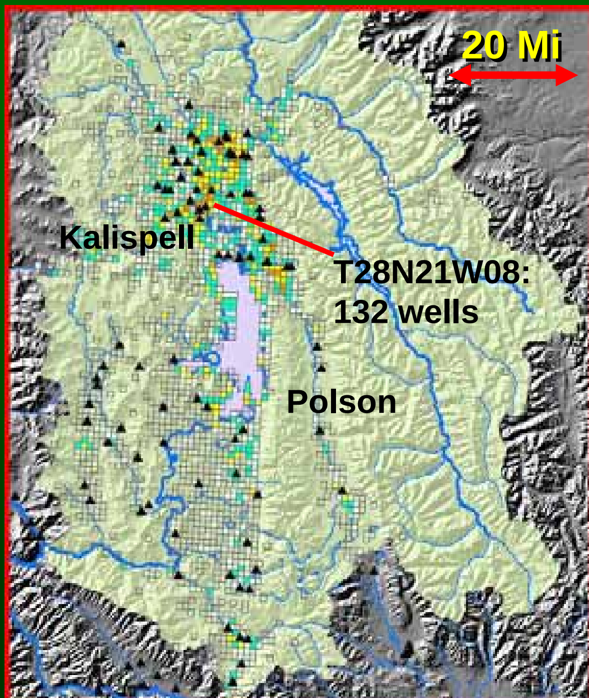
| | Min. | Med. | Max |
|---|---|---|---|
| Meas. | 32 | 39 | 42 |
| Years | 10 | 11.5 | 13 |

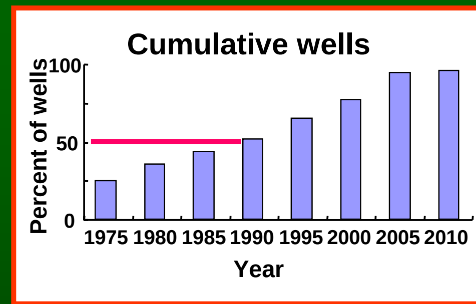
**Total wells in basin: 6**

**One monitoring well / 422 wells**

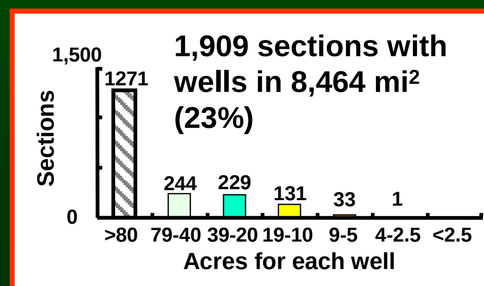
# Flathead River above Paradise

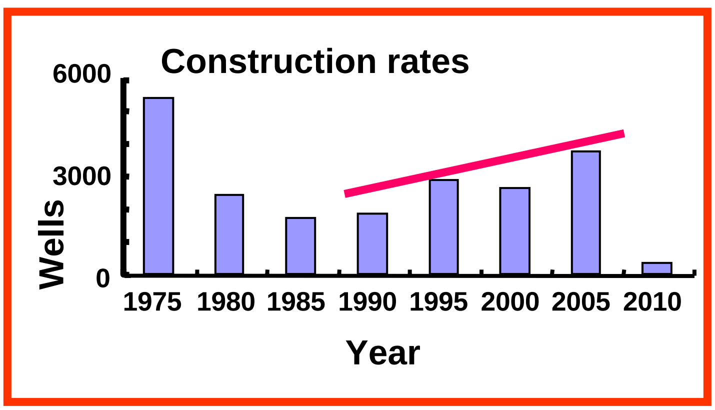
**20,897 wells: 86% domestic**

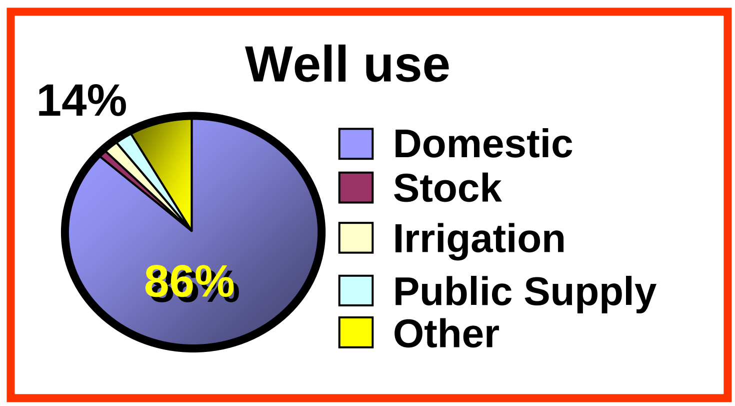


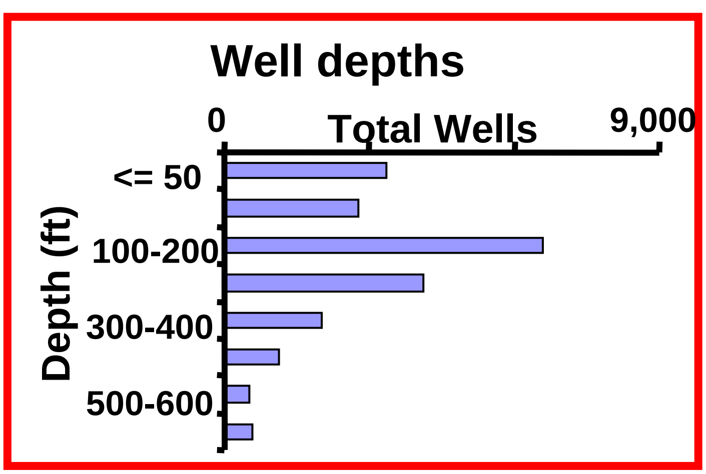




- 1 well/40 ac.
- 1 well/20 ac.
- 1 well/10 ac.
- 1 well/5 ac.
- 1 well/2.5 ac.
- 1 well/<2.5 ac.

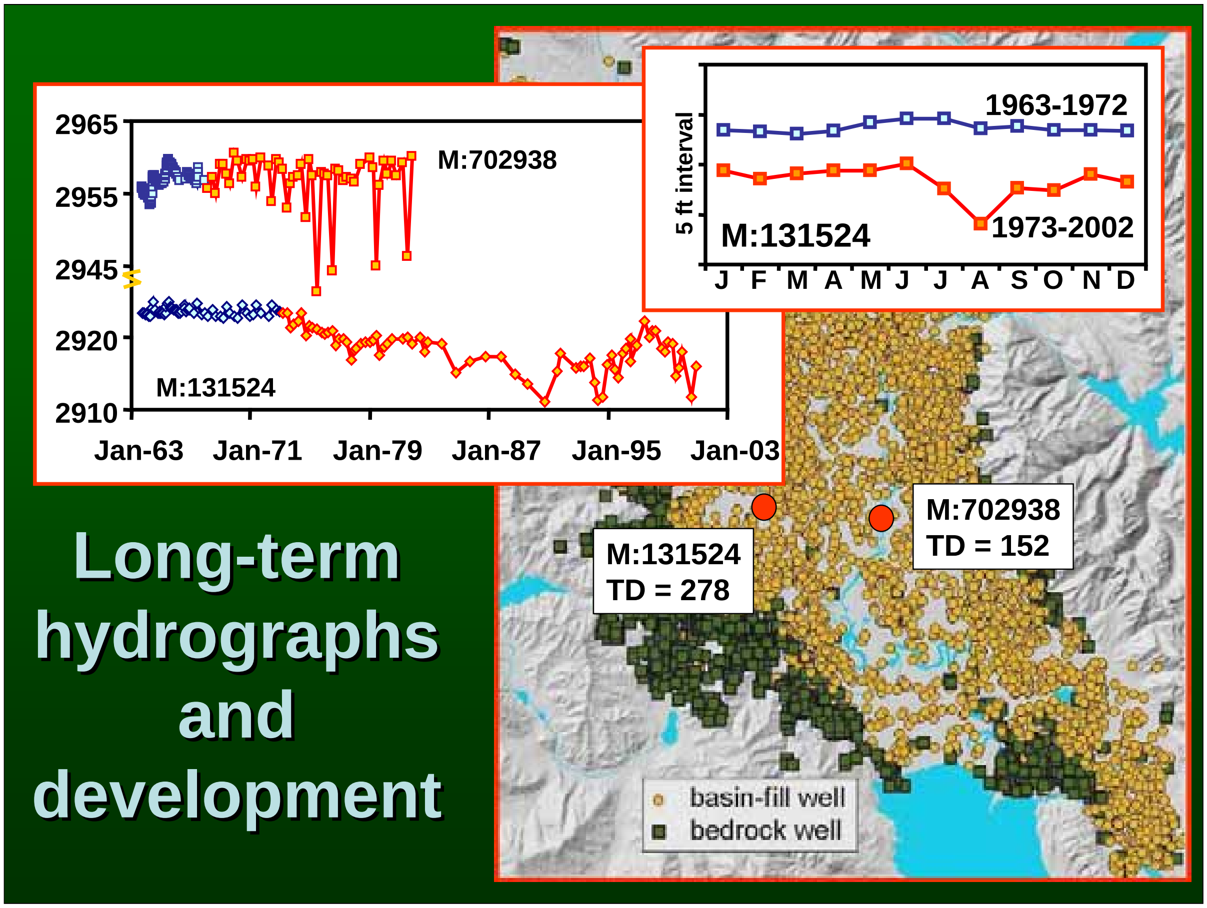


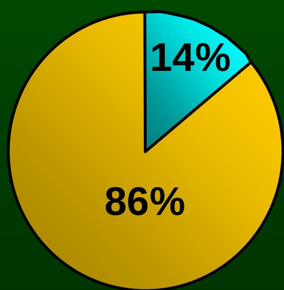



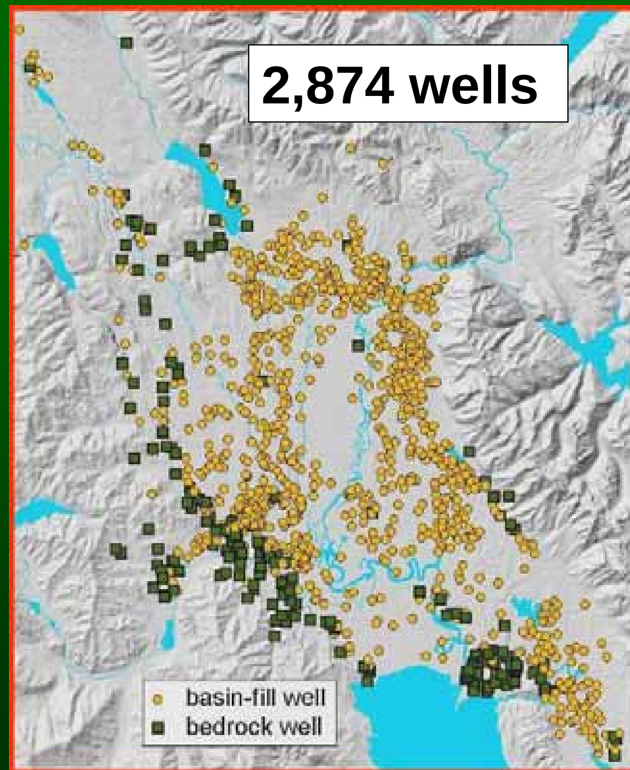




| State wide Monitoring | | | |
|---|---|---|---|
| | Min. | Med. | Max |
| Meas. | 26 | 79 | 7,664 |
| Years | 5 | 14 | 63 |
| Total wells in basin: 91 | | | |
| One monitoring well / 230 wells | | | |

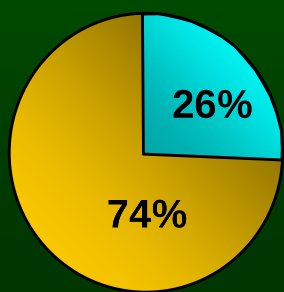

Long-term hydrographs and development
2965
2955
2945
2920
2910
Jan-63
Jan-71
Jan-79
Jan-87
Jan-95
Jan-03
M:702938
M:131524
5 ft interval
1963-1972
1973-2002
M:131524
J F M A M J J A S O N D
M:702938
TD = 152
M:131524
TD = 278
basin-fill well
bedrock well

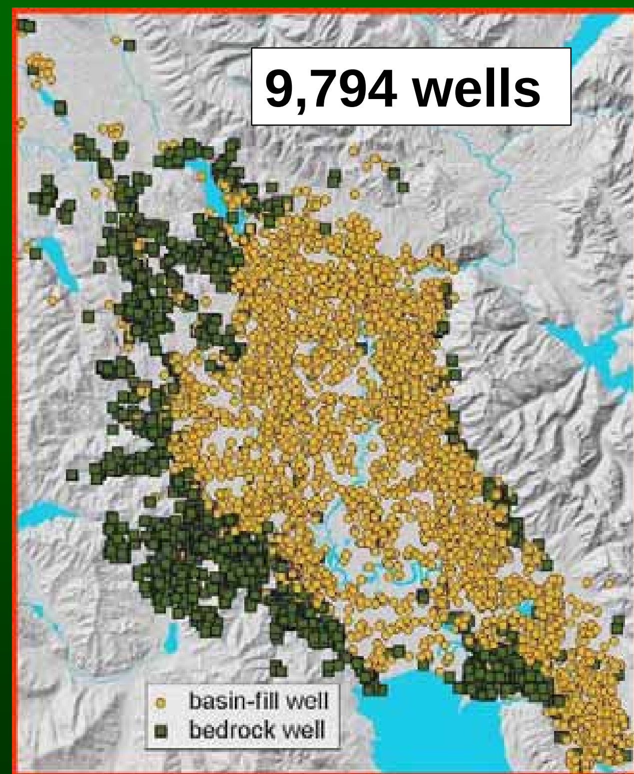
# Bedrock aquifer development: Kalispell Valley-- 1975



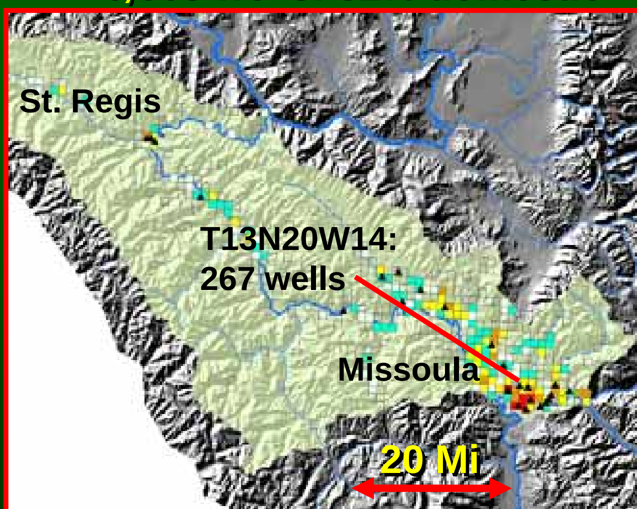
# Bedrock aquifer development: Kalispell Valley-- 2001

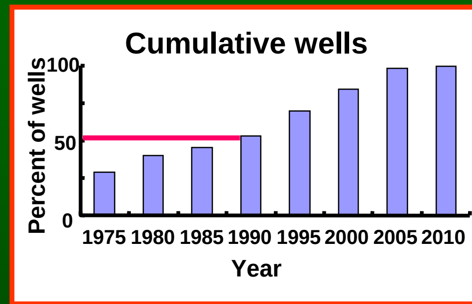


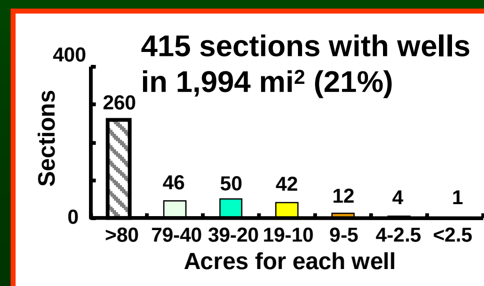
# Middle Clark Fork

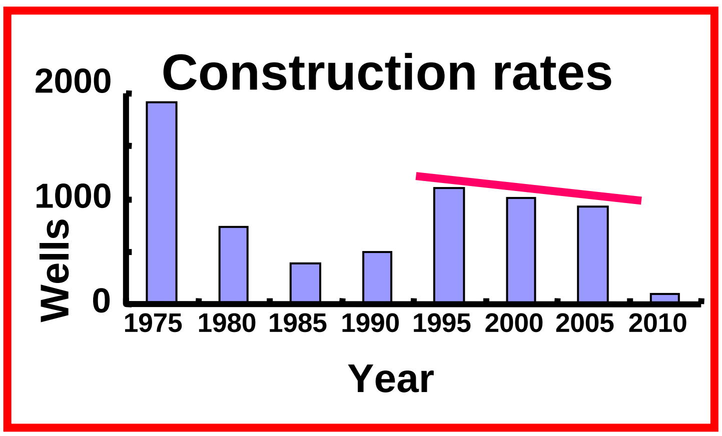
6,663 wells: 82% domestic

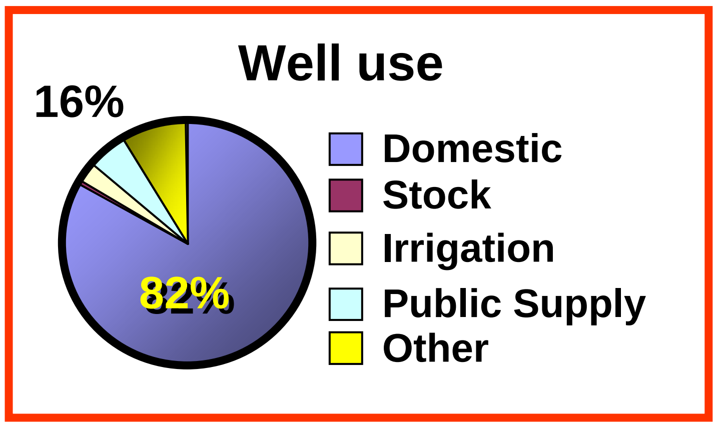


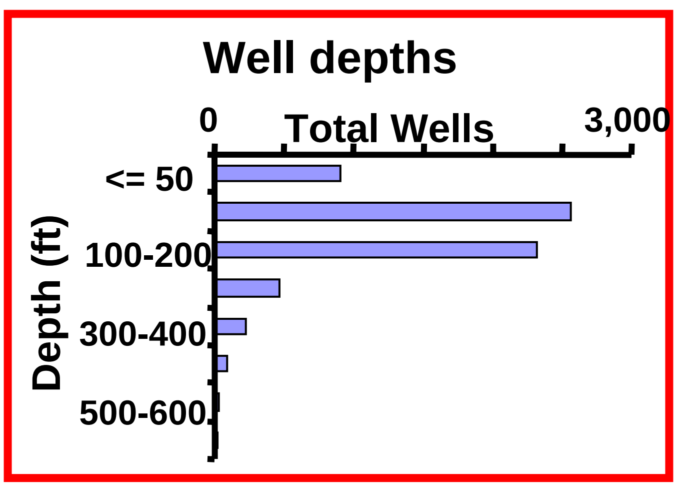




1 well/40 ac.
1 well/20 ac.
1 well/10 ac.
1 well/5 ac.
1 well/2.5 ac.
1 well/<2.5 ac.



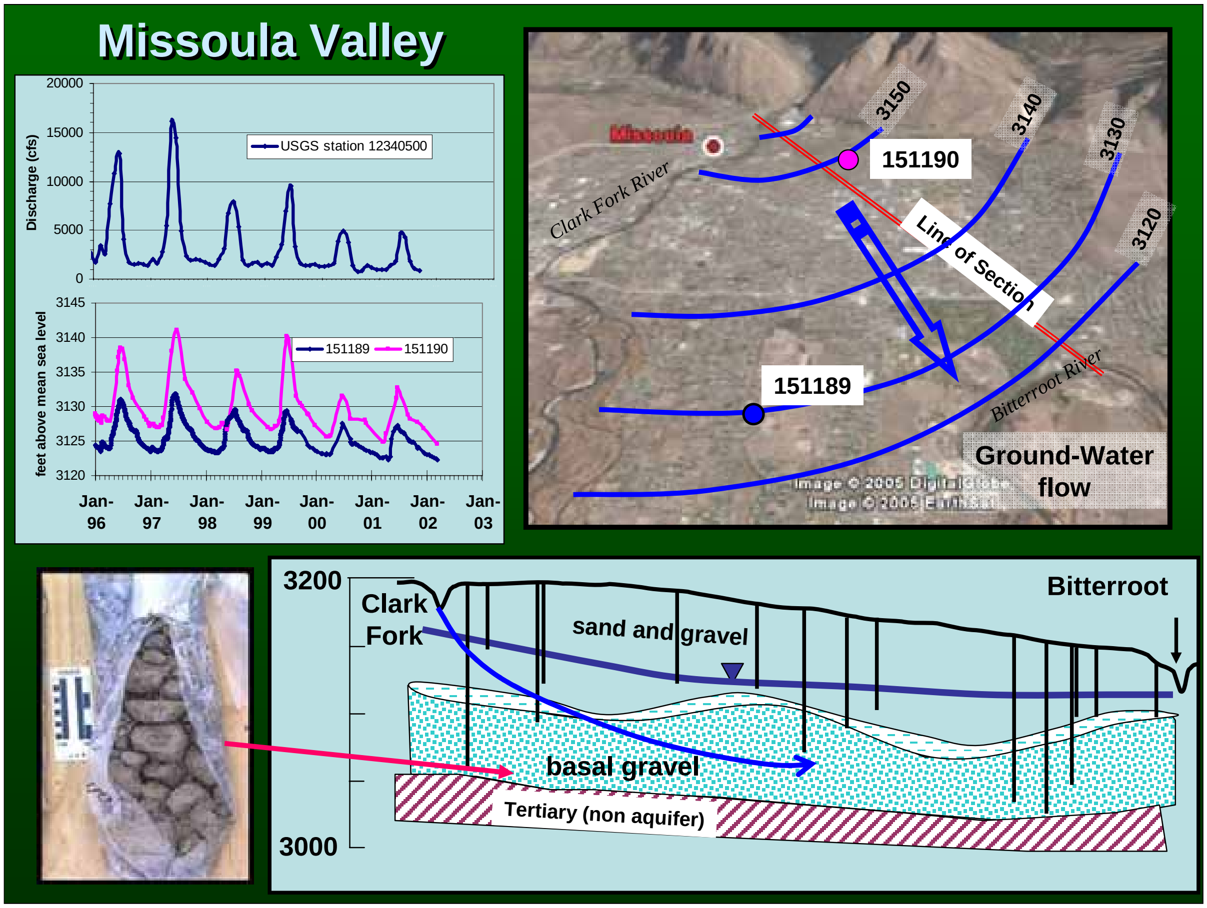



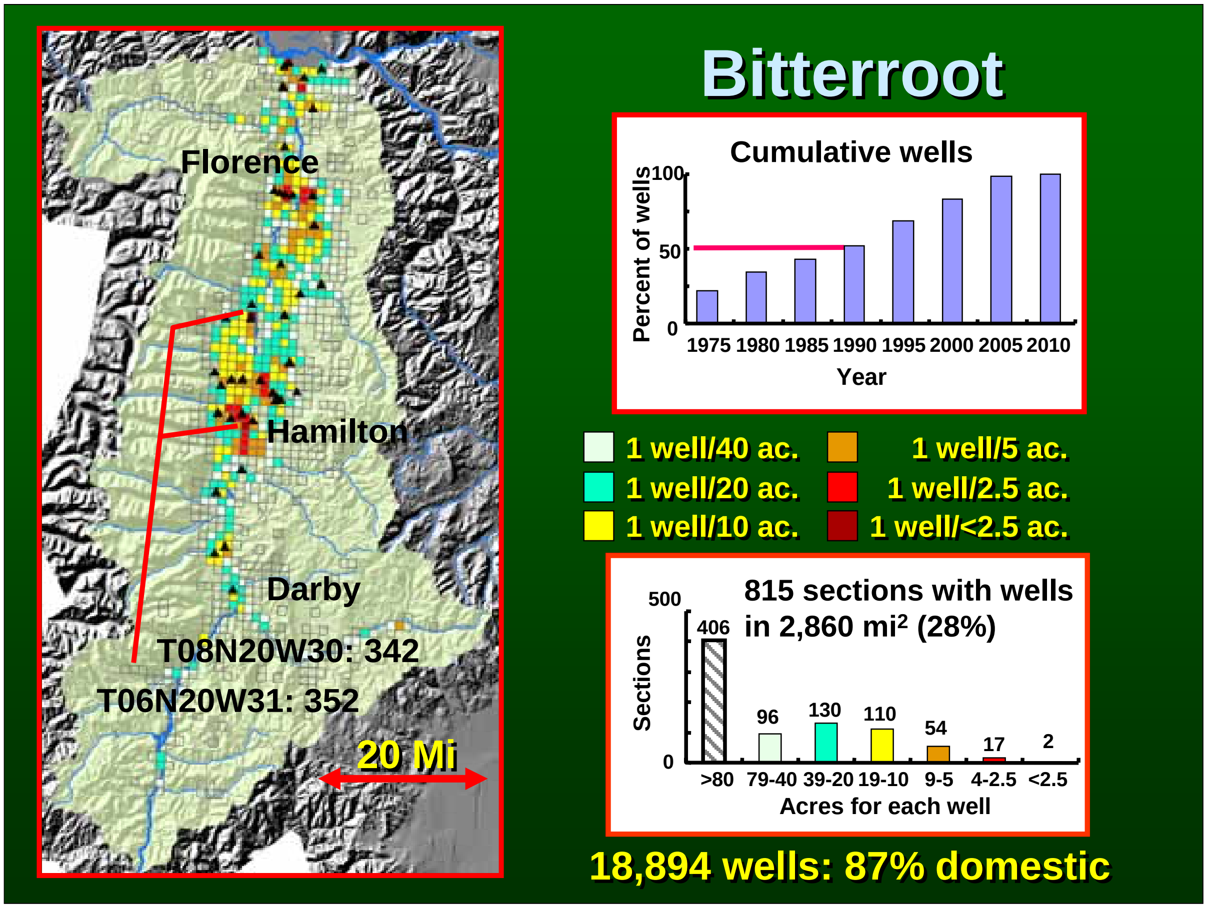

## State wide Monitoring

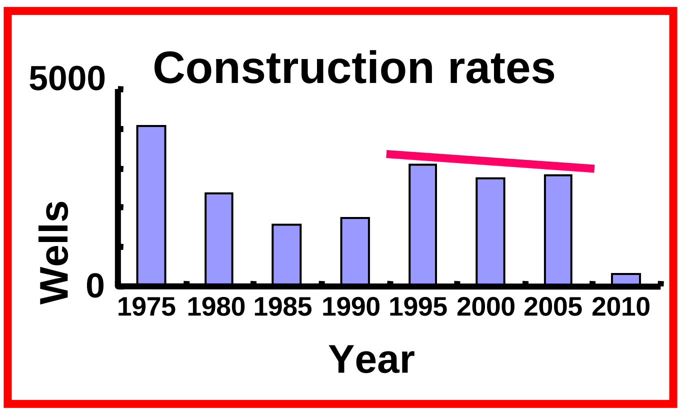
| | Min. | Med. | Max |
|---|---|---|---|
| Meas. | 27 | 40 | 7,662 |
| Years | 6 | 11 | 21 |

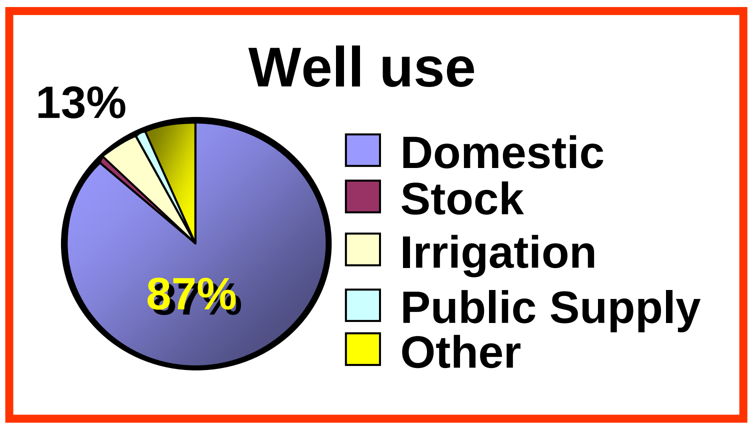
Total wells in basin: 24

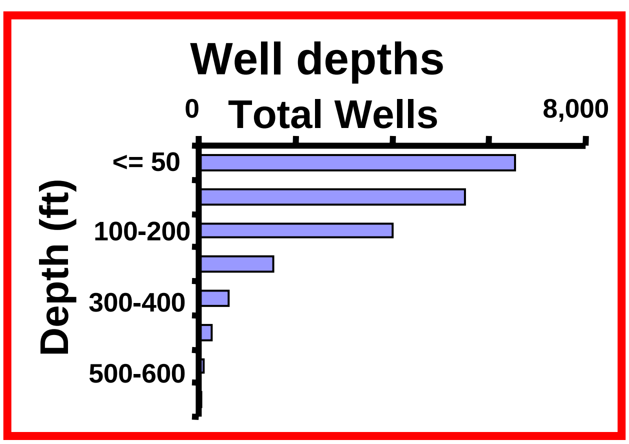
One monitoring well / 281 wells


Missoula Valley
Discharge (cfs)
USGS station 12340500
feet above mean sea level
151189
151190
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Clark Fork River
3150
3140
3130
3120
Line of Section
Bitterroot River
Ground-Water flow
Image © 2005 DigitalGlobe
Image © 2005 EarthSat
3200
3000
Clark Fork
sand and gravel
basal gravel
Tertiary (non aquifer)
Bitterroot



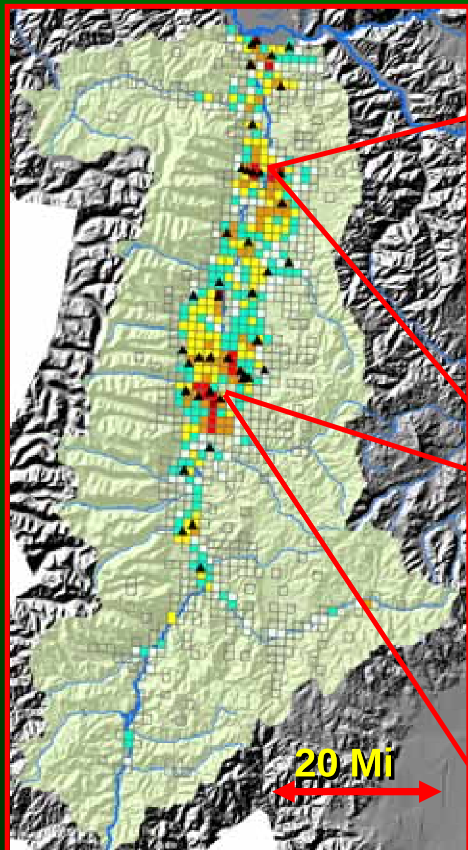

**State wide Monitoring**

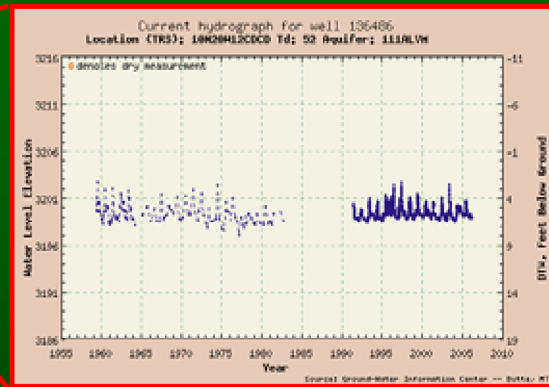
| | Min. | Med. | Max |
|---|---|---|---|
| **Meas.** | 1 | 75 | 7,647 |
| **Years** | 0 | 12 | 50 |

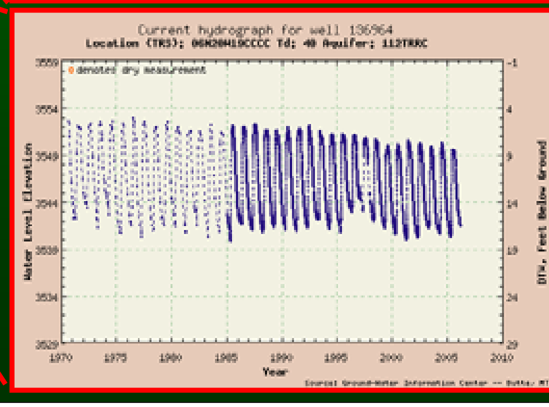
**Total wells in basin: 43**

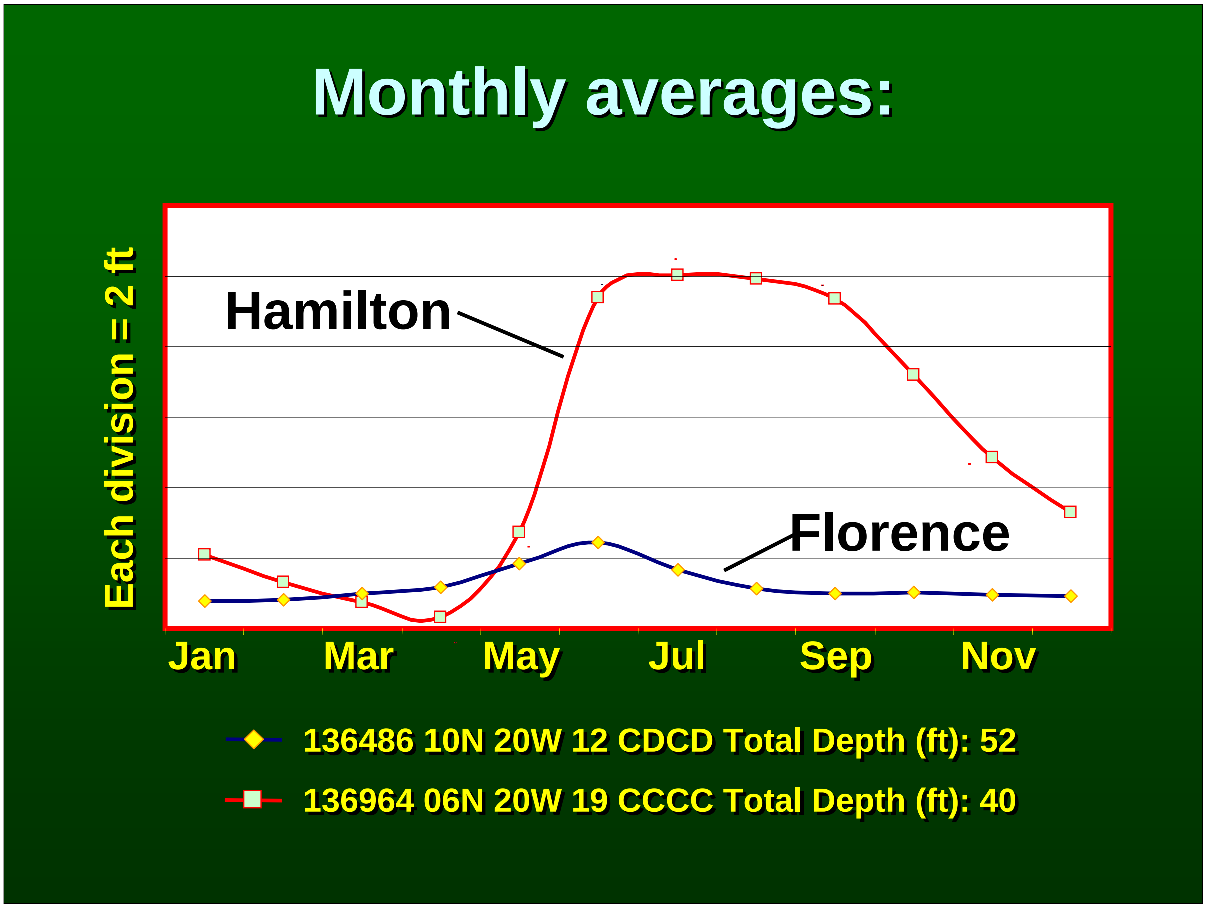
**One monitoring well / 439 wells**

# Irrigation influence



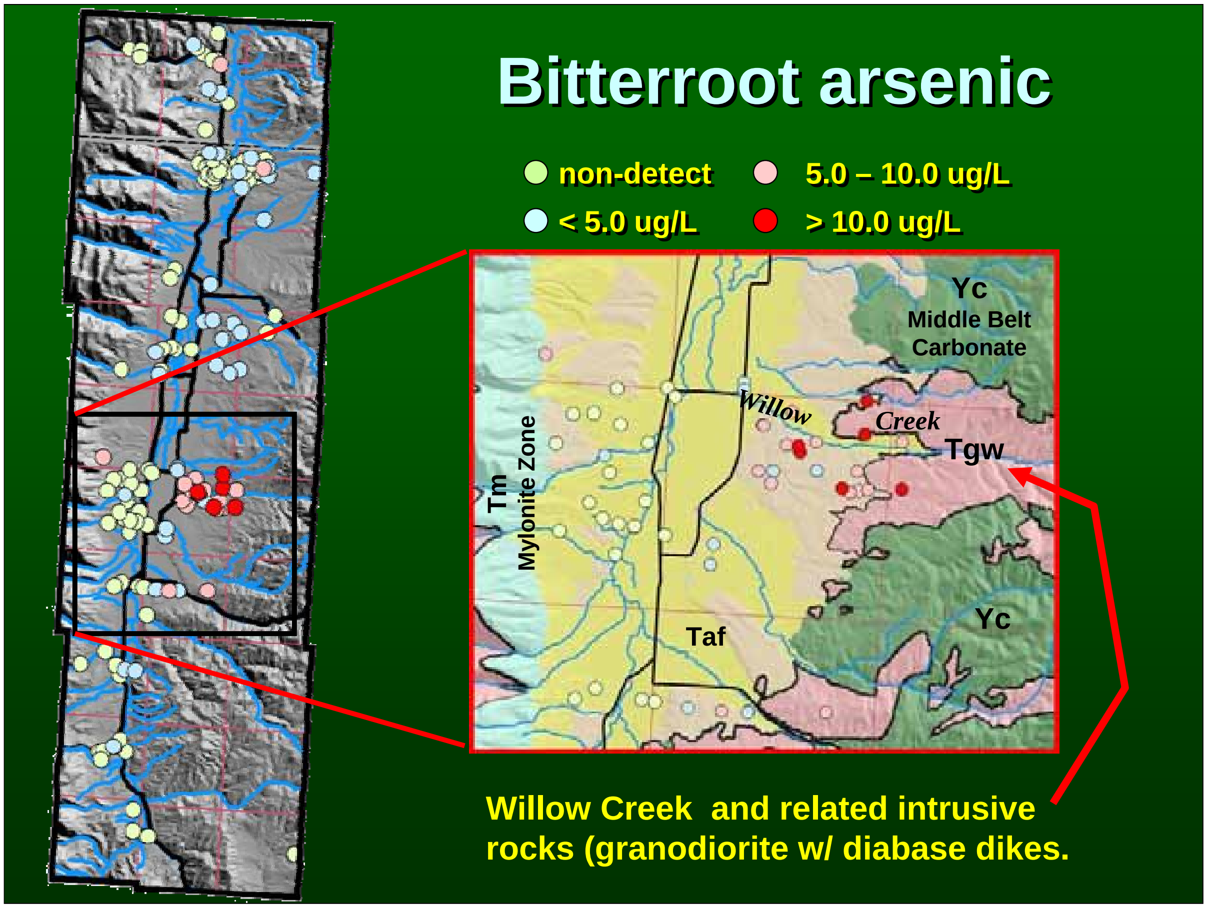



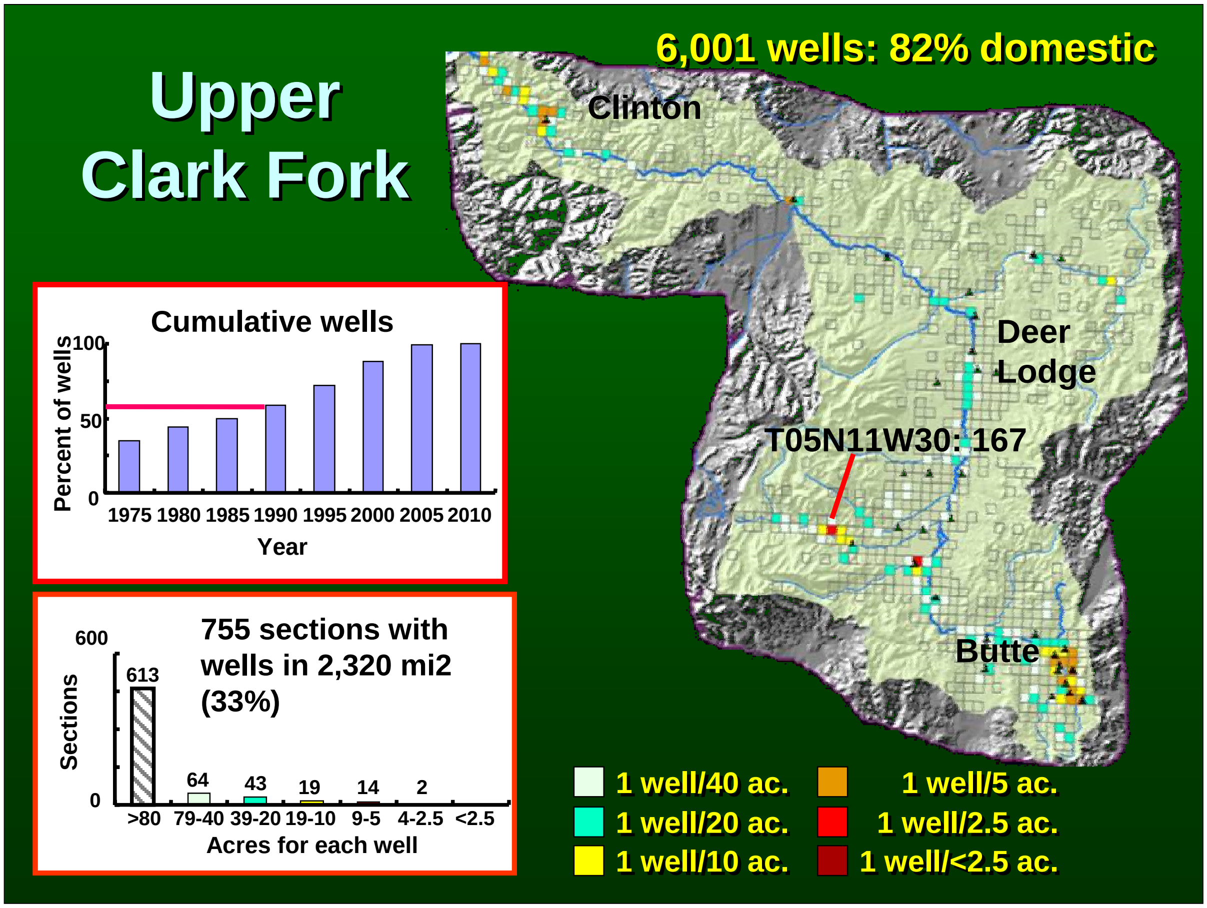


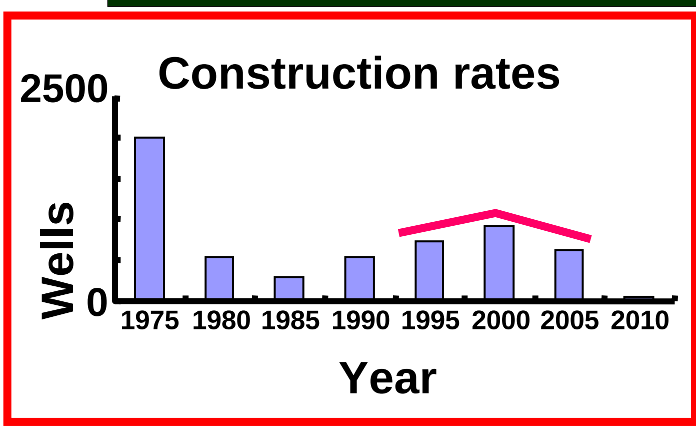

**Surface and ground-water interaction**

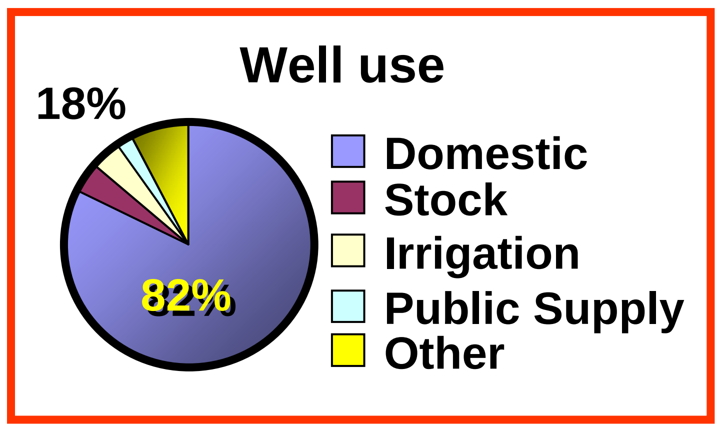
Wells that are in aquifers heavily dependent on the distribution of surface water for irrigation have typical hydrographs similar to the Hamilton well. Water levels begin to rise quickly during a 1-2 month period after the irrigation season begins. Continual application of water throughout the irrigation season supports the water table at a high level. After irrigation water is turned off in the late summer or fall, water levels begin to fall. Wells that are in aquifers related to direct recharge by rivers or streams have hydrographs that more or less follow the discharge as recorded in the stream. Water levels will peak near the time that stream flow peaks and begin to fall back to a base level.

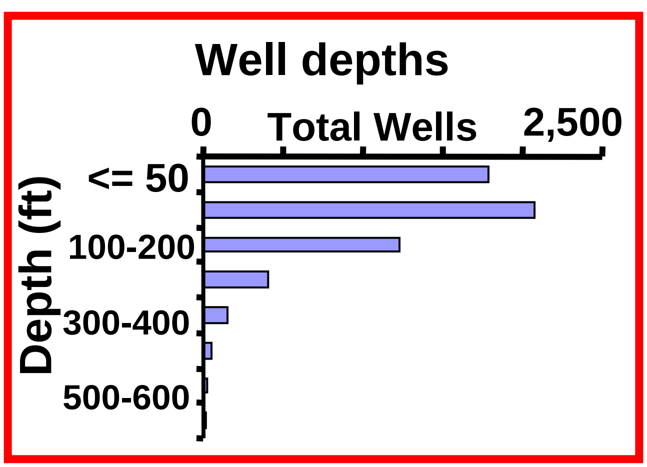


Bitterroot arsenic
non-detect
5.0 – 10.0 ug/L
< 5.0 ug/L
> 10.0 ug/L
Yc
Middle Belt
Carbonate
Willow
Creek
Tgw
Tm
Mylonite Zone
Taf
Yc
Willow Creek and related intrusive rocks (granodiorite w/ diabase dikes.



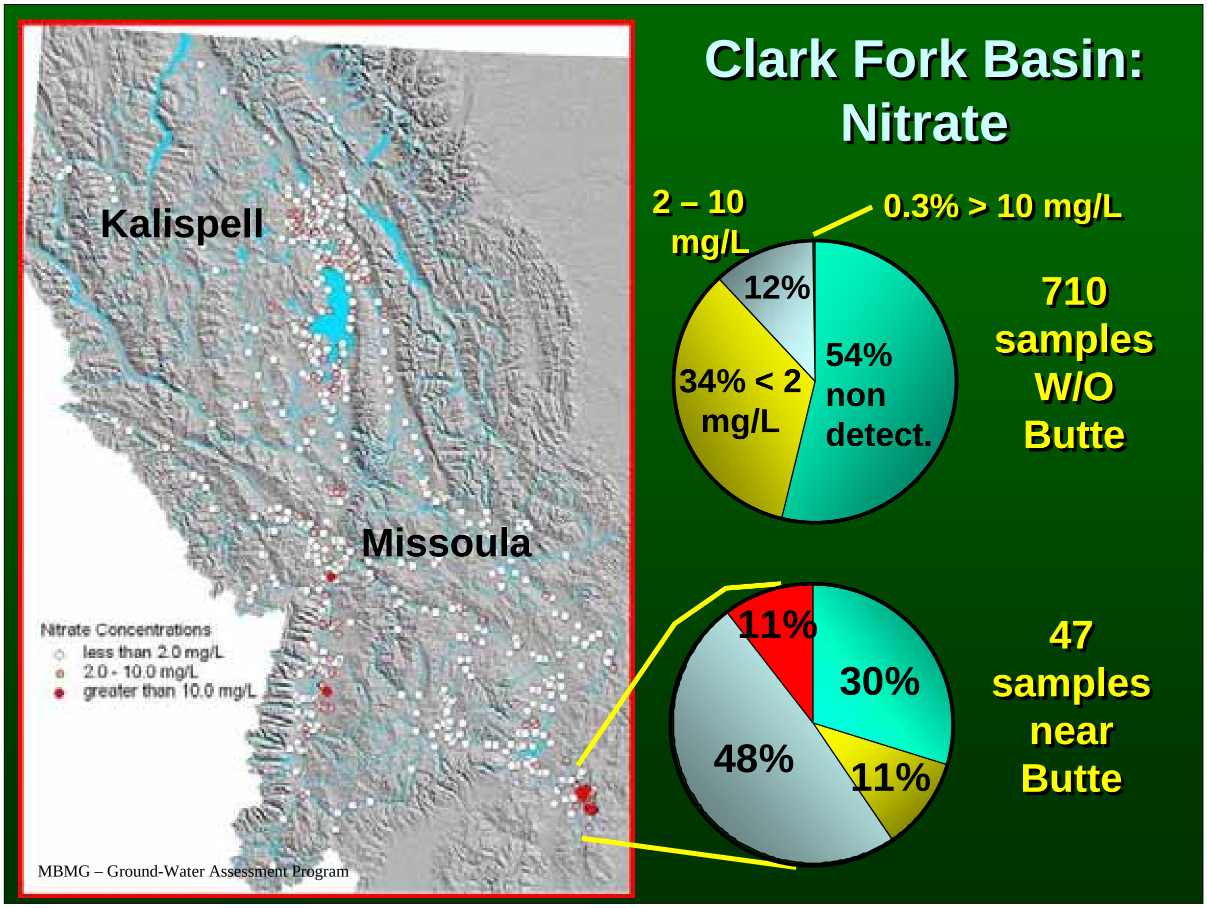



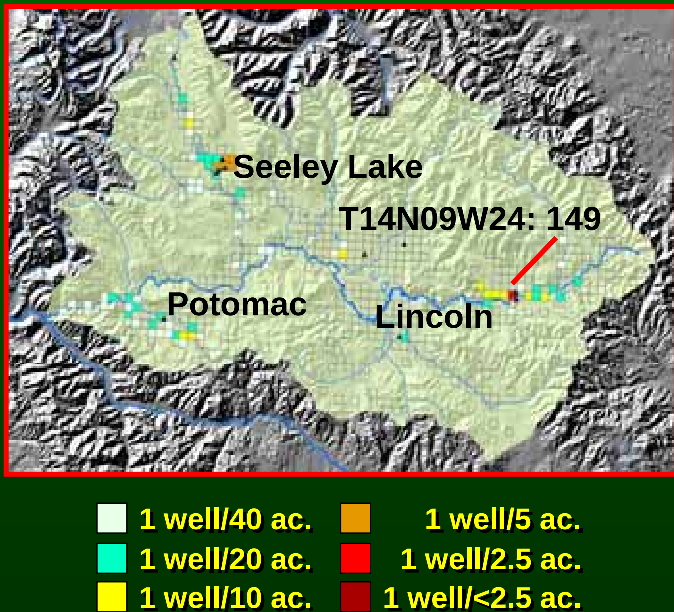

## State wide Monitoring

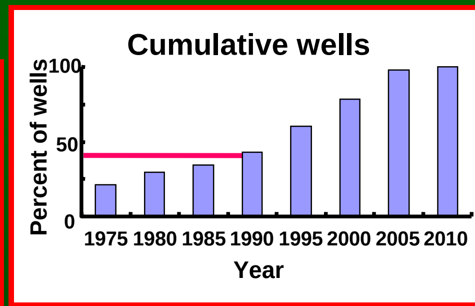
| | Min. | Med. | Max |
|---|---|---|---|
| Meas. | 14 | 74 | 8,499 |
| Years | 1 | 14 | 46 |
| Total wells in basin: 24 | | | |
| One monitoring well / 250 wells | | | |

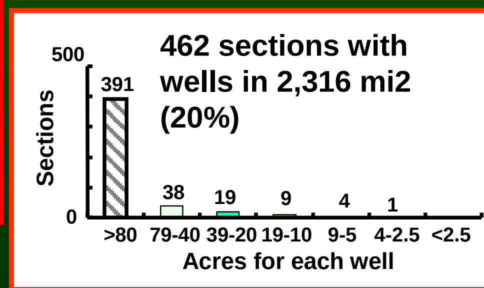

Clark Fork Basin: Nitrate
Kalispell
Missoula
Nitrate Concentrations
less than 2.0 mg/L
2.0 - 10.0 mg/L
greater than 10.0 mg/L
MBMG – Ground-Water Assessment Program
2 – 10 mg/L
0.3% > 10 mg/L
12%
34% < 2 mg/L
54% non detect.
710 samples W/O Butte
11%
30%
48%
11%
47 samples near Butte

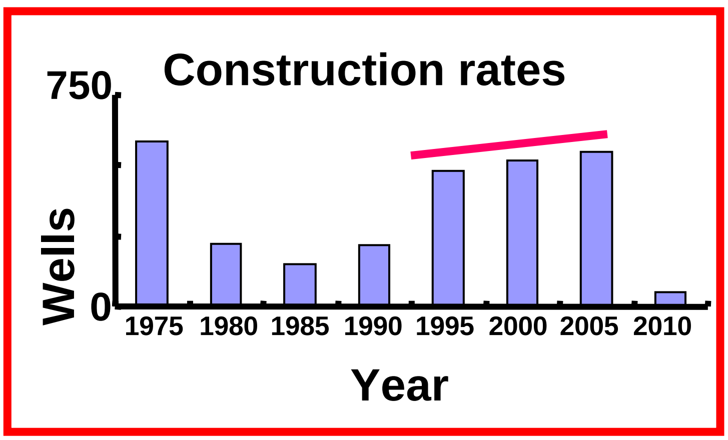
# Blackfoot Basin

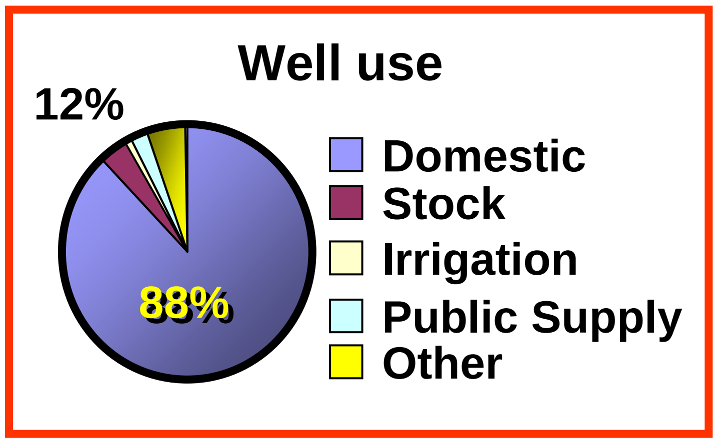
**2,769 wells: 88% domestic**

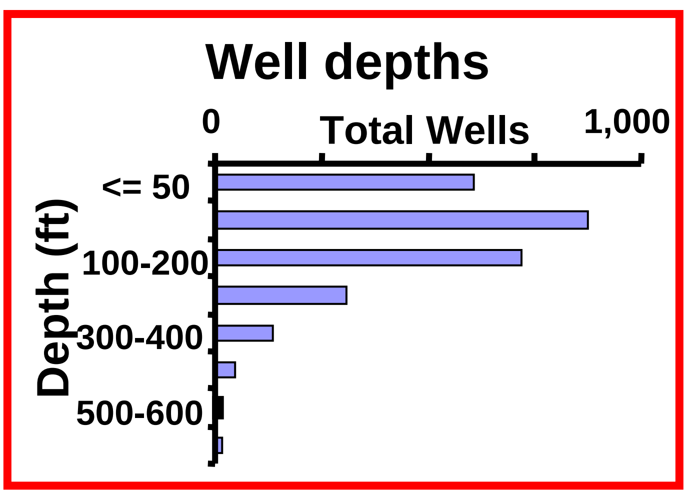


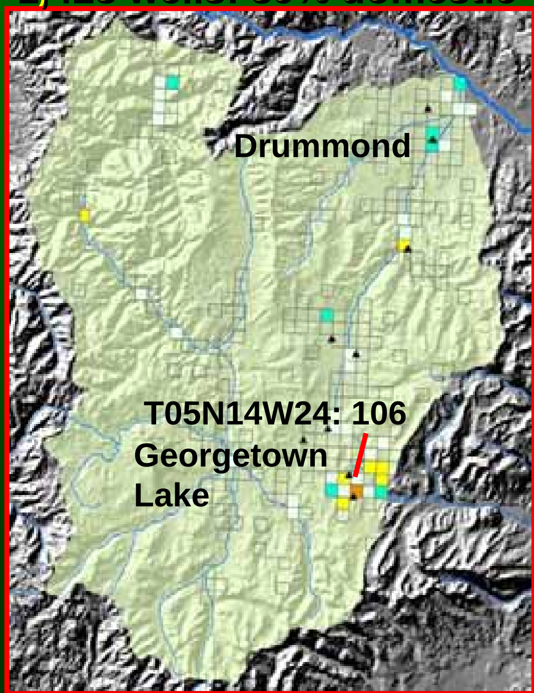



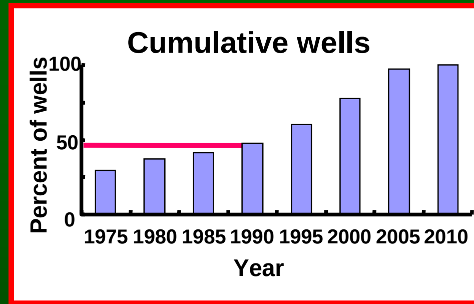



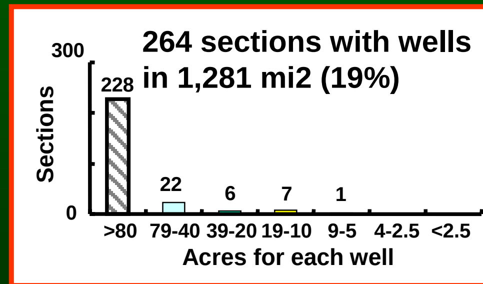

| State wide Monitoring | | | |
|---|---|---|---|
| | Min. | Med. | Max |
| **Meas.** | 34 | 57 | 5,176 |
| **Years** | 6 | 11.5 | 31 |
| **Total wells in basin: 10** | | | |
| **One monitoring well / 279 wells** | | | |

# Rock and Flint Creek Basins

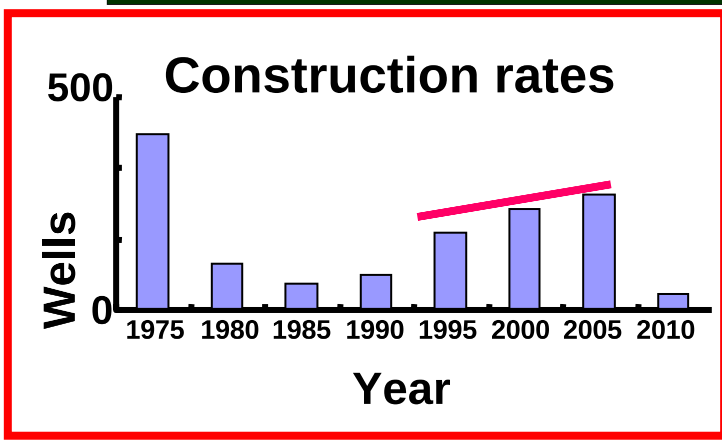
**1,428 wells: 89% domestic**

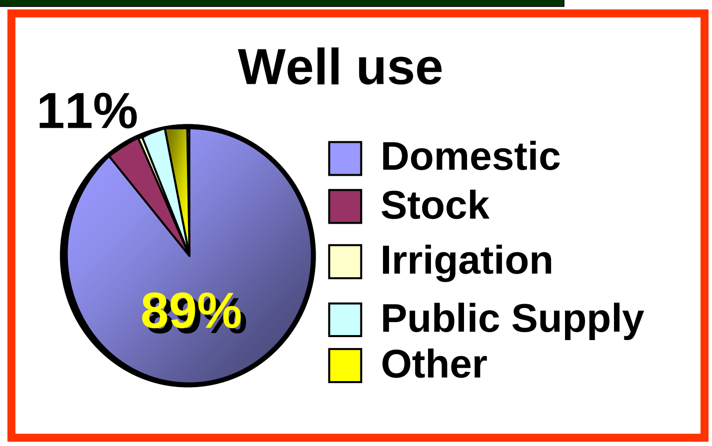


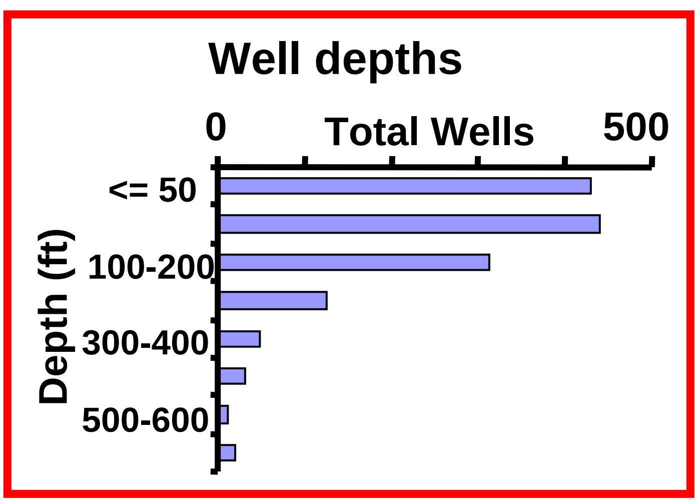




1 well/40 ac.
1 well/20 ac.
1 well/10 ac.
1 well/5 ac.
1 well/2.5 ac.
1 well/<2.5 ac.

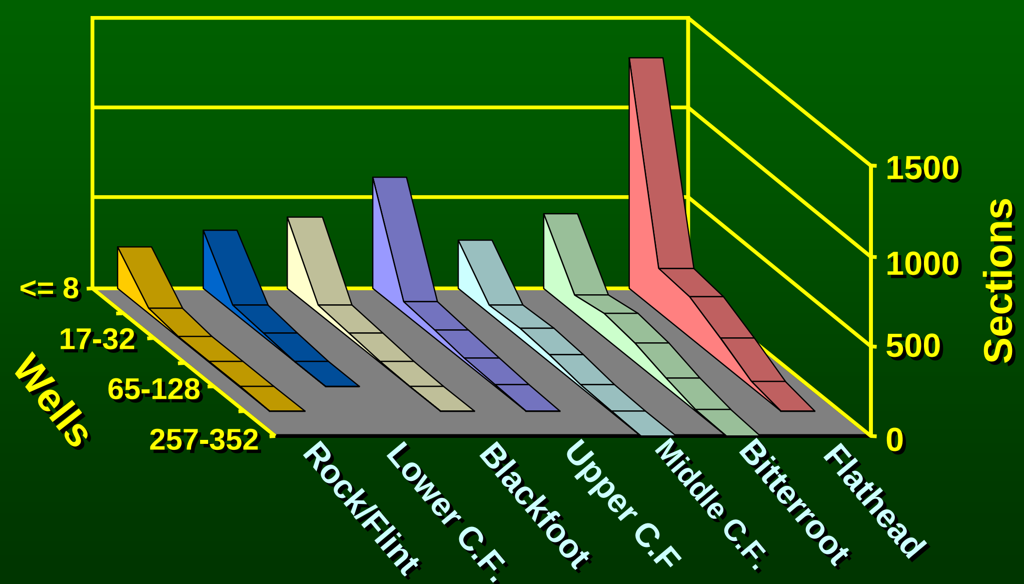


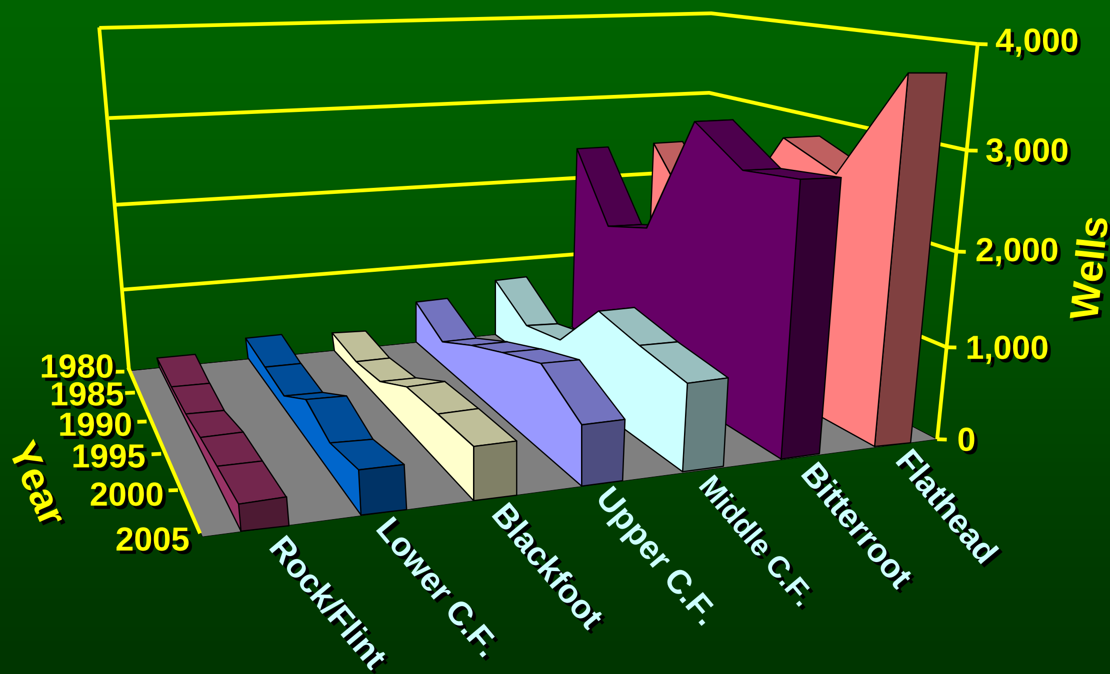



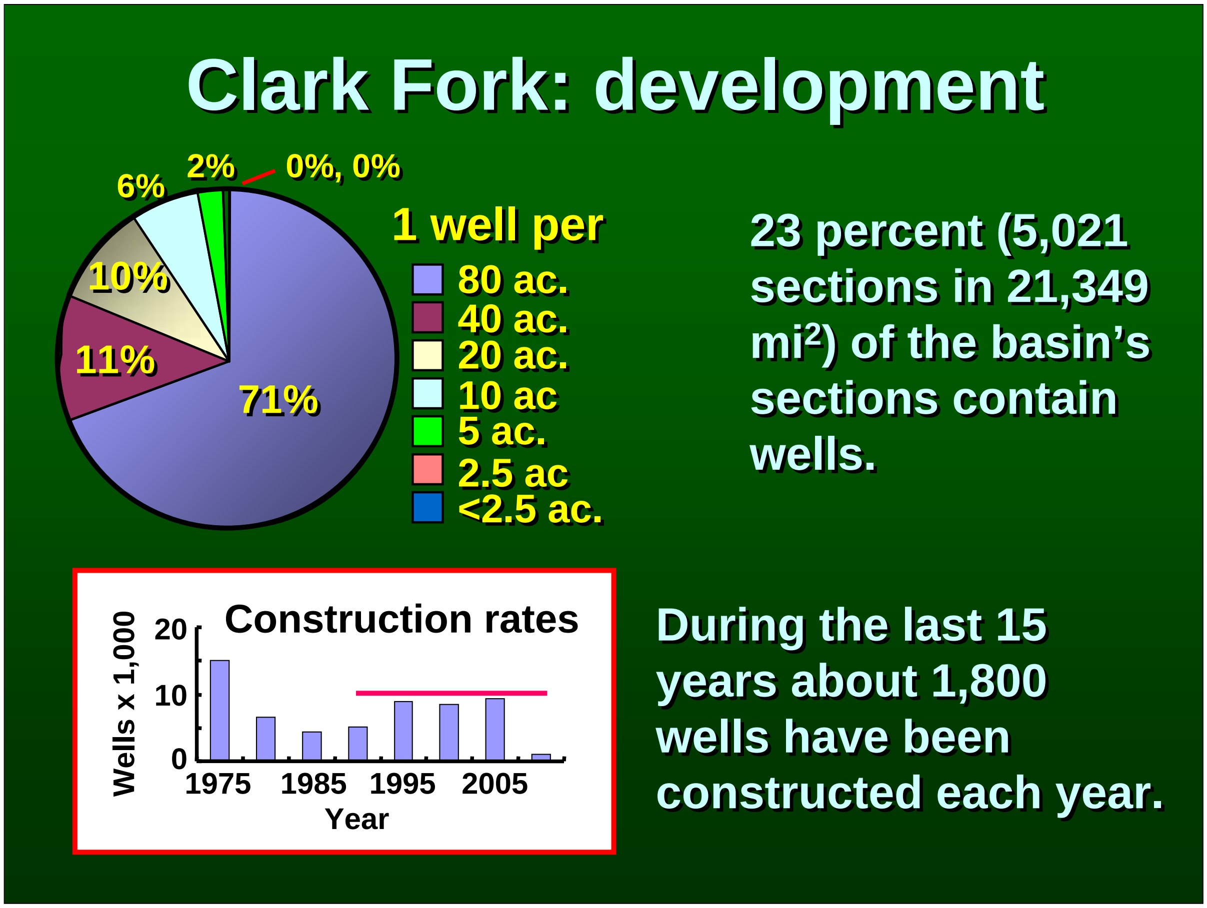

| State wide Monitoring | | | |
|---|---|---|---|
| | Min. | Med. | Max |
| Meas. | 49 | 80 | 8,248 |
| Years | 6 | 11.5 | 13 |
| Total wells in basin: 9 | | | |
| One monitoring well / 159 wells | | | |

# Clark Fork: well densities



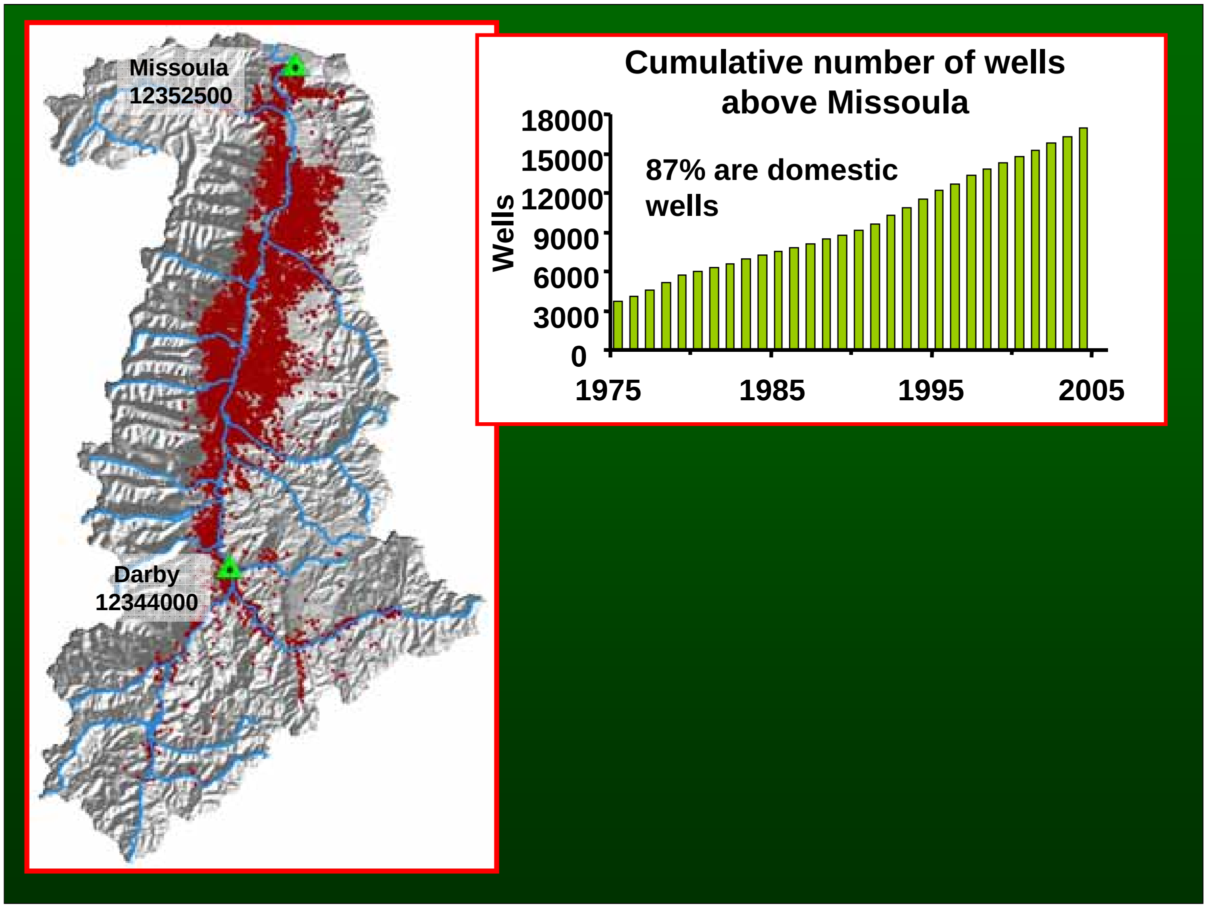
# Clark Fork: drilling rates

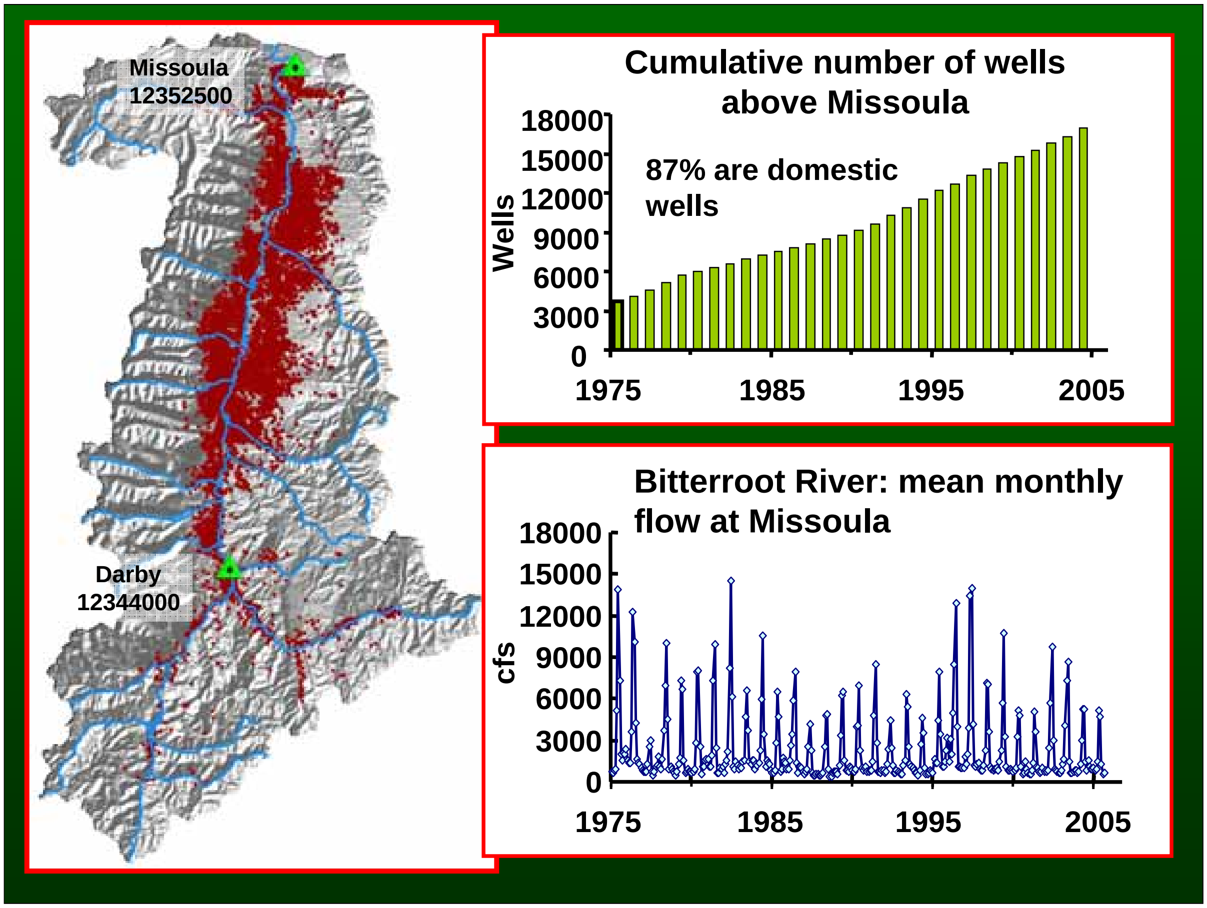


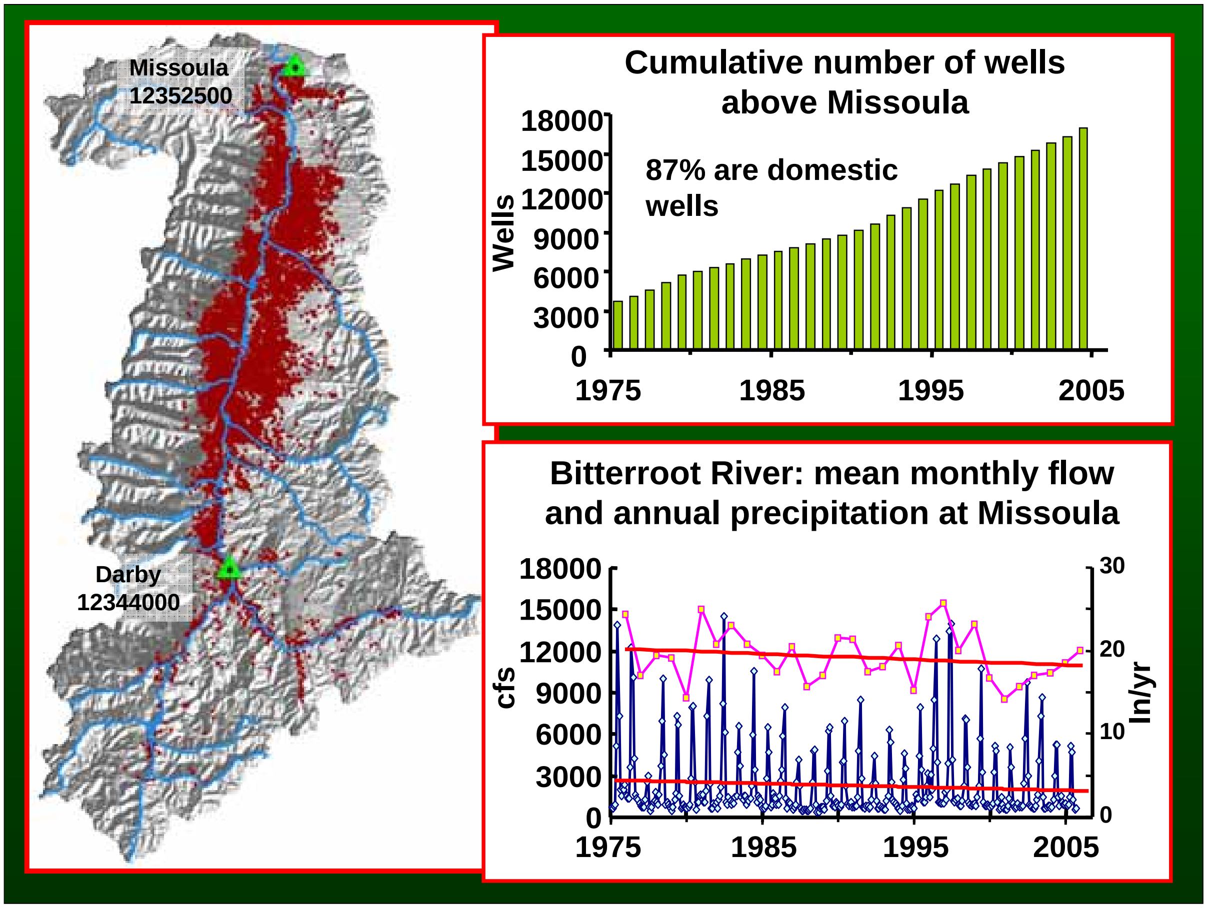

Clark Fork: development
6%
2%
0%, 0%
10%
11%
71%
1 well per
80 ac.
40 ac.
20 ac.
10 ac
5 ac.
2.5 ac
<2.5 ac.
23 percent (5,021 sections in 21,349 mi²) of the basin's sections contain wells.
Construction rates
Wells x 1,000
20
10
0
1975
1985
1995
2005
Year
During the last 15 years about 1,800 wells have been constructed each year.

# Summary: a water balance?

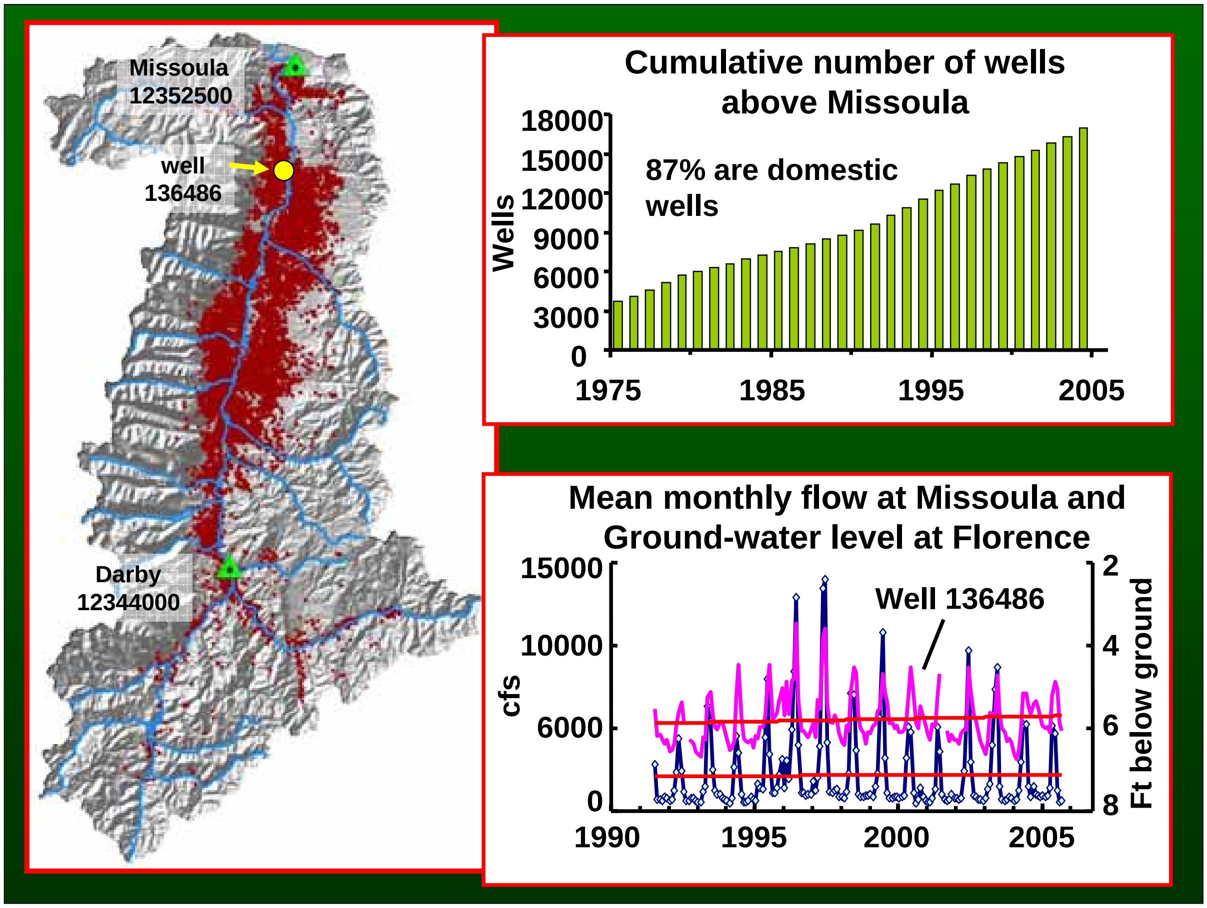
| | Million A/f | Sources |
|---|---|---|
| Precipitation | 22.06 | 1971-2004 average based on Western Climate Division data. |
| Discharge | 13.74 | 1971-2004 average annual discharge near Plains. |
| Irrigation | 0.28 | MT DNRC water rights listings for irrigation use – September 2006. |
| Municipal | 0.21 | MT DNRC water rights listings for municipal use – September 2006. |
| Domestic | 0.08 | ~ 52,000 wells @ 1.5 af consumptive use each. |
| Evap./ET | 7.75 | By difference. |


Missoula
12352500
Darby
12344000
Cumulative number of wells above Missoula
87% are domestic wells
Wells
18000
15000
12000
9000
6000
3000
0
1975
1985
1995
2005

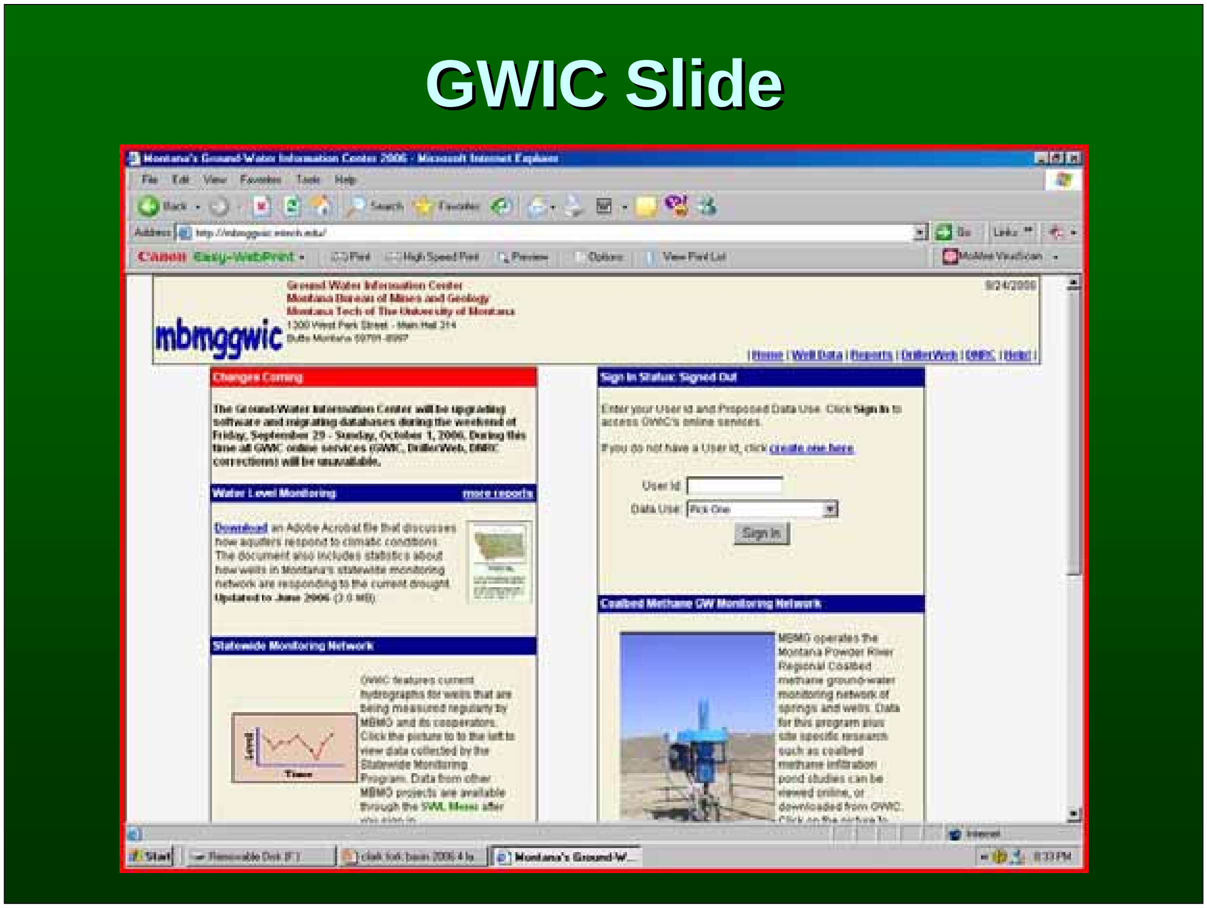

Missoula
12352500
Darby
12344000
Cumulative number of wells above Missoula
87% are domestic wells
Wells
18000
15000
12000
9000
6000
3000
0
1975
1985
1995
2005
Bitterroot River: mean monthly flow at Missoula
cfs
18000
15000
12000
9000
6000
3000
0
1975
1985
1995
2005



Missoula
12352500
Darby
12344000
Cumulative number of wells above Missoula
87% are domestic wells
Wells
18000
15000
12000
9000
6000
3000
0
1975
1985
1995
2005
Bitterroot River: mean monthly flow and annual precipitation at Missoula
cfs
In/yr
30
20
10
0



Missoula
12352500
well
136486
Darby
12344000
Cumulative number of wells above Missoula
87% are domestic wells
Wells
18000
15000
12000
9000
6000
3000
0
1975
1985
1995
2005
Mean monthly flow at Missoula and Ground-water level at Florence
Well 136486
cfs
15000
10000
6000
0
1990
1995
2000
2005
Ft below ground
2
4
6
8




Most of the ground-water information presented today can be obtained from the Ground-Water Information Center at the Montana Bureau of Mines and Geology.

Well logs, water-quality data, water-level data and Ground-Water Characterization Program maps products can be obtained from the website at http\:mbmggwic.mtech.edu.

Well 101131: 01S 16E 28 BADC-
Stillwater County (unused)

# Montana Ground-Water Assessment

**September 27, 2006**

Montana Bureau of Mines and Geology
Since 1919
Earth Science Information